

SECTION 6

SUBCATEGORIZATION

This section presents a discussion on subcategorization for today's iron and steel effluent limitations guidelines and standards. Section 6.1 presents background on EPA's subcategorization process and describes the factors EPA evaluated for this rulemaking. Section 6.2 presents information on the proposed subcategorization structure. Section 6.3 presents the final subcategorization analyses, structure, and rationale, and describes each of the subcategories and segments.

6.1 Subcategorization Factors

The CWA requires EPA, in developing effluent limitations guidelines and standards, to consider a number of different factors (Section 304(b)(2)(b), 33 U.S.C. § 1314 (b)(2)(B)). Among others, these factors include

- Age of equipment and facilities;
- Location;
- Size of site;
- Manufacturing processes employed;
- Wastewater characteristics; and
- Non-water quality environmental impacts.

One way the Agency has taken some of these factors into account is by breaking down categories of industries into separate classes of similar characteristics. This recognizes the major differences among companies within an industry that may reflect, for example, different manufacturing processes or other factors.

EPA considered all the relevant factors in developing the subcategorization structure for the existing iron and steel regulation, which is based on manufacturing operation and/or product produced. In developing today's final rule for the iron and steel industry, EPA reviewed the existing subcategorization structure to determine whether it is still appropriate. EPA used information from industry survey data, EPA site visits, sampling data, and public comments (discussed in Chapter 2) to re-evaluate and consider each of the statutory factors listed above as they affect the current industry.

For both the proposed and final rule, EPA concluded that, like the existing subcategorization structure, the majority of these factors do not support subcategorization. EPA first evaluated the age of facilities with respect to production-normalized wastewater discharge rates (volume of water discharged with respect to production). The comparison between the age of the facilities and the respective process wastewater discharge rates showed no relationships between mill age and the volume of process wastewater discharged. Therefore, the Agency determined that the age of facilities and equipment did not have an impact on wastewater generation or discharge. The Agency's analysis of age versus wastewater discharge rate are

located in the administrative record for the rule. (See DCNs IS10357, IS10359, IS10362, and IS10441 of Section 14.1 of the Administrative Record.)

Similarly, the Agency also evaluated age with respect to installing or upgrading wastewater treatment equipment and found that while a site or a plant may have been operating for several decades, manufacturing and treatment system upgrades regularly occur. In certain cases, older sites actually have modern wastewater treatment systems and have demonstrated model BAT treatment. Consequently, the Agency has determined that subcategorization was not warranted on the basis of age. (See DCN IS04614 of Section 5.2 of the Administrative Record.)

The Agency analyzed location of the sites with respect to the amount of process wastewater discharged. While the Agency realizes that facilities located in arid and semi-arid regions of the country have greater opportunity for decreased discharge flow rates due to water loss from evaporation, the flow allowances used to develop the final regulation have been determined to be achievable in any region of the country. Therefore, the Agency determined that location was not a significant criterion for subcategorization. The data from EPA's analysis of location versus wastewater discharge rate are located in the administrative record for this rule. (See DCNs IS10357, IS10359, IS10362, and IS10441 of Section 14.1 of the Administrative Record.)

While larger iron and steel sites discharge greater total volumes of wastewater, the size of a site (e.g., acreage, number of employees) did not have an impact on production-normalized wastewater discharge rates or pollutant concentrations. Consequently, the Agency determined that size was also not a significant factor for subcategorization. (See DCNs IS10357, IS10359, IS10362, and IS10441 of Section 14.1 of the Administrative Record.)

Similarly, EPA evaluated non-water quality impacts, such as solid waste and air emission effects, and determined that non-water quality environmental impacts did not constitute a basis for subcategorization in the final rule. A detailed discussion of non-water quality impacts is presented in Section 15.

Of all the subcategorization criteria, EPA identified manufacturing processes as the most significant factor affecting the final subcategorization structure because it had the greatest impact on wastewater generation and characteristics. In addition, EPA used type of product and wastewater characteristics, including flow rates with respect to production and type of pollutant present, to segment within each subcategory. A detailed discussion of wastewater sources, pollutant loadings, option selection, regulated pollutants, and production-normalized flow rates for each segment is presented in Sections 7, 9, 11, 12, and 13 of this document.

Since many of the elements considered for subcategorization, including statutory factors, have not changed since the 1982 rule, refer to Volume I of the Technical Development for the 1982 regulation (pages 155 to 163, EPA 440/1-82/024, May 1982) for a more detailed review of the above factors.

6.2 Proposed Subcategorization

On December 27, 2000, EPA proposed a subcategorization structure that was significantly different from the structure in the 1982 iron and steel rule (see 65 FR 81964, 81974-81975). The Agency proposed to revise the subcategorization structure to create seven subcategories of iron and steel facilities based on co-treatment of compatible waste streams. This would have replaced the present structure of 12 subcategories. EPA proposed the following seven subcategories:

| Subpart | Subcategory | Segment |
|-----------|---|---|
| Subpart A | Cokemaking Subcategory | By-Product Recovery Non-Recovery |
| Subpart B | Ironmaking Subcategory | Blast Furnace Sintering |
| Subpart C | Steelmaking Subcategory | |
| Subpart D | Integrated and Stand-Alone Hot Forming Mills Subcategory | Carbon and Alloy Stainless |
| Subpart E | Non-Integrated Steelmaking and Hot Forming Operations Subcategory | Carbon and Alloy Stainless |
| Subpart F | Steel Finishing Subcategory | Carbon and Alloy Stainless |
| Subpart G | Other Operations Subcategory | Direct-Reduced Ironmaking Forging Briquetting |

The Agency proposed to consolidate sintering and ironmaking into a single “ironmaking subcategory.” Additionally, the Agency consolidated steelmaking processes combining basic oxygen furnace (BOF), vacuum degassing, and continuous casting into the “steelmaking subcategory.” The Agency also attempted to separate integrated mills hot forming operations from non-integrated mills operations (electric arc furnace steelmaking, vacuum degassing, continuous casting, and hot forming). Unlike the 1982 rule, EPA proposed to consolidate operations such as salt bath descaling, acid pickling, and other finishing operations into a single “steel finishing subcategory.” In addition, one new subcategory, “other operations subcategory,” has been created to regulate direct-reduced ironmaking, briquetting, and forging.

In addition to the revised subcategory structure, EPA proposed segmentation changes in the proposed cokemaking, ironmaking (sintering), integrated steelmaking, integrated and stand-alone hot forming, non-integrated steelmaking and hot forming, and finishing subcategories. First, EPA proposed to combine two 1982 segments in the cokemaking subcategory, “iron and steel” and “merchant,” into a single “by-product recovery” segment because differences in wastewater flow rates observed in the 1982 rulemaking are no longer apparent within the current population of by-product coke plants. In addition to combining all by-product recovery cokemaking operations into one segment, the Agency also proposed a new

“non-recovery” segment to accommodate the two non-recovery coke plants. Second, for the proposed integrated and stand-alone hot forming subcategory, the non-integrated steelmaking and hot forming subcategory, and the steel finishing subcategory, EPA proposed segmenting based on whether facilities primarily make stainless or carbon/alloy steels.

The Agency proposed this subcategorization structure to reflect not only the modern state of the industry, in terms of both process and wastewater management, but also the experience that the Agency and other regulatory entities have gained from implementing the 1982 iron and steel effluent limitations guidelines and standards. EPA also expected that the revised subcategorization structure would simplify the regulatory process and reflect co-treatment of compatible wastewaters, which is currently practiced by the industry. As a result, many of the proposed subcategories would have included various operations that are regulated under different segments or subcategories in the 1982 rule.

Table 6-1 presents a comparison of the 1982 subcategorization structure and the structure EPA proposed on December 27, 2000. For a detailed discussion of the proposed subcategorization, see Section 6 of the Development Document for the Proposed Iron and Steel Manufacturing Point Source Category, EPA 831-B-00-011, December 2000.

6.3 Final Subcategorization

While EPA did not receive any comments specific to the proposed subcategorization structure, the Agency did receive a number of comments on the change in segmentation for the cokemaking subcategory. The comments opposed EPA’s proposal to drop the segmentation of “iron and steel” and “merchant” coke plants; however, the comments agree with EPA’s assessment that production process and wastewaters from these types of plants coke plants are similar. The Agency also evaluated potential economic differences among these plants in order to see whether they justified retaining the 1982 segmentation. Although some difference in facility size was observed, EPA did not find substantial differences in profitability or other factors that might affect economic achievability. Some commenters also expressed confusion regarding the segmentation of stainless and carbon/alloy steels.

Following proposal, the Agency re-evaluated the economic conditions and technology bases of the proposed rule. The Agency decided to promulgate new or revised limits for only three subcategories (cokemaking, sintering, and other operations), and for segments within two others (ironmaking and steelmaking). These decisions similarly affected the final subcategorization structure. Due to the small number of subcategories affected by today’s rule, the Agency has decided to retain the 1982 subcategory structure with the addition of an “other operations subcategory.” As a result, the final rule covers the following 13 subcategories:

| Subcategory | Description |
|---------------|--|
| Subcategory A | Cokemaking (includes by-product recovery and non-recovery operations) |
| Subcategory B | Sintering (includes wet and dry air pollution control operations) |
| Subcategory C | Ironmaking |
| Subcategory D | Steelmaking (includes basic oxygen furnace and electric arc furnace operations) |
| Subcategory E | Vacuum degassing |
| Subcategory F | Continuous casting |
| Subcategory G | Hot forming |
| Subcategory H | Salt bath descaling |
| Subcategory I | Acid pickling |
| Subcategory J | Cold forming |
| Subcategory K | Alkaline cleaning |
| Subcategory L | Hot coating |
| Subcategory M | Other operations (includes forging, direct-reduced ironmaking, and briquetting operations) |

For the cokemaking subcategory, this final rule combines the “iron and steel” and “merchant” segments into a newly-created “by-product recovery” cokemaking segment for most regulatory purposes, although EPA is retaining the “iron and steel” and “merchant” segments for purposes of reflecting the existing BPT/BCT limitations. EPA is also creating a new cokemaking segment for non-recovery operations and a new sintering segment for dry air pollution control systems. Because the promulgated rule makes no change to subcategorization for the steelmaking, hot forming, vacuum degassing, casting, or various finishing operations, the segmentation for these operations in the 1982 rule remains applicable. Finally, the Agency is creating a new subcategory, the “other operations subcategory.” The complete final subcategorization structure is presented in Table 6-2. A detailed discussion of each subcategory, in the structure of the 2000 proposal follows.

6.3.1 Proposed Subpart A: Cokemaking

Cokemaking turns carbon in raw coal into metallurgical coke, which is subsequently used in the ironmaking process. There are two types of cokemaking operations: by-product recovery and non-recovery. In by-product coke plants, metallurgical coke is produced by distilling coal in refractory-lined, slot-type ovens at high temperatures in the absence of air. In non-recovery coke plants, coal is made into coke in negative pressure, higher temperature coke ovens.

In by-product coke operations, the moisture and volatile components generated from the coal distillation process are collected and processed to recover by-products, such as crude coal tars, light crude oil, etc. Non-recovery cokemaking facilities use higher temperature ovens which destroy volatile organics, and they do not recover any by-products.

In by-product recovery coke plants, wastewater such as waste ammonia liquor is generated from moisture contained in the coal charge to the coke ovens, and some wastewater is generated from the by-product recovery operations. The non-recovery coke plants, on the other hand, do not generate process wastewater other than boiler blowdown and process storm water, which are typically disposed of by coke quenching.

The 1982 regulation segmented by-product recovery cokemaking into “iron and steel” and “merchant” coke plants. “Iron and steel” cokemaking was defined at 420.11(d) and “merchant” cokemaking was defined at 420.11(c). The term “iron and steel” means those by-product recovery cokemaking operations other than merchant cokemaking operations. “Merchant” means those by-product recovery cokemaking operations which provide more than fifty percent of the coke produced to operations, industries, or processes other than iron making blast furnaces associated with steel production. The proposed subdivision was created to reflect different wastewater volume generation rates between coke plants located at integrated steel plants and at merchant coke plants.

In December 2000, EPA proposed to combine the iron and steel and merchant cokemaking segments into a single segment: by-product recovery cokemaking. EPA proposed this change because its analyses showed that wastewater generation and characteristics, and pollution prevention and wastewater treatment technology effectiveness for the two segments were similar. In 1982, EPA determined that the model flow rates for “iron and steel” coke plants and merchant coke plants, including control water, were 153 gpt and 170 gpt, respectively. However, EPA did not observe these differences in wastewater generation rates when analyzing the current survey data.

Comments opposed EPA’s proposal to drop the segmentation on the basis of “iron and steel” and “merchant” coke plants based on economic considerations. However, the comments agreed with EPA’s assessment that production process and wastewaters characteristics and flow rates from merchant coke plants are similar to those from the integrated “iron and steel” facilities. The Agency evaluated potential economic differences between “merchant” and “iron and steel” facilities and found no substantial differences in profitability or other factors which might affect economic achievability, although some difference in facility size was observed. This facility size was not significant and not considered adequate for subcategorization. (See DCN IS11044 of Section 15.1.4, and DCN IS10362 of Section 14.1, of the Administrative Record.)

Consequently, for the cokemaking subcategory, today’s rule combines the “iron and steel” and “merchant” segments into a newly-created “by-product recovery” cokemaking segment for most regulatory purposes, although EPA is retaining the “iron and steel” and “merchant” segments for purposes of reflecting the existing BPT limitations. EPA concluded

that this was appropriate because the production processes, wastewater characteristics, wastewater flow rates, and economic impacts from all by-product recovery cokemaking operations, including merchant facilities, are similar.

The non-recovery cokemaking segment includes non-recovery cokemaking processes that have either existed for many years or are currently emerging in the industry. Other than low-volume boiler blowdown and process area storm water, non-recovery cokemaking processes do not generate wastewater like the by-product recovery processes do. This major difference in wastewater flow necessitated the segmentation of this subcategory.

6.3.2 Proposed Subpart B: Ironmaking

In ironmaking, blast furnaces are used to produce molten iron, which makes up about two-thirds of the charge to basic oxygen steelmaking furnaces. The raw materials charged to the top of the blast furnace include coke, limestone, refined iron ores, and sinter. Preheated air is blown into the bottom of the furnace and exits the furnace top as blast furnace gas in enclosed piping. The off-gas is cleaned and cooled in a combination of dry dust catchers and high-energy venturi scrubbers. Direct contact water used in the gas coolers and high-energy scrubbers comprises nearly all of the wastewater from ironmaking blast furnace operations.

Sinter plants upgrade the iron content of ores and recover iron from a mixture of wastewater treatment sludges, mill scale from integrated steel mills, and fine coke particles (also known as coke breeze) from cokemaking operations. In sinter plants, the iron source mixture is combined with limestone and charged to a furnace. Sinter of suitable size and weight is formed for charging to the blast furnace. Wastewaters are generated from wet air pollution control devices on the wind box and discharge ends of the sinter furnace. No process wastewater is generated by dry air pollution control systems.

The 1982 regulation distinguished sintering and blast furnace operations as two separate subcategories, sintering and ironmaking, respectively. In 2000, EPA proposed to combine these two subcategories together into a single “ironmaking” subcategory. EPA proposed this change because survey responses indicated that facilities with both operations generate wastewater with similar characteristics and tended to co-mingle these wastewaters before treatment¹. However, EPA concluded that it was still appropriate to distinguish between the two in terms of model system flow rates and manufacturing process, and proposed to divide the ironmaking subcategory into the sintering and blast furnace segments. The Agency proposed to further divide the sintering segment due to differences in wastewater generation, as discussed below.

Sinter facilities use two types of air pollution control systems to treat air emissions from sinter plants: wet and dry. Sinter plants that operate dry air pollution controls do

¹An exception is that EPA found dioxins and furans in wastestreams from sinter operations with wet air pollution control systems and in blast furnace wastewaters cotreated with sintering wastewaters. No measurable dioxins and furans were found in treated blast furnace wastewater only.

not generate process wastewater. Data from the surveys indicate that approximately a third of these plants employ dry air pollution controls. EPA proposed to establish a segment for sintering plants with dry air pollution control and designate the discharge requirements to be zero discharge of pollutants.

In response to comments received on the proposal, EPA generally concluded it was not appropriate to revise the existing limitations and standards for the proposed ironmaking subcategory (with the exception of codifying an ammonia waiver). Consequently, EPA is similarly retaining the existing subcategorization structure for sintering and ironmaking. However, EPA did not receive any comments opposing the segmentation of sintering on the basis of air pollution control systems. Therefore, the final rule creates two segments the sintering subcategory: dry air pollution control and wet air pollution control.

6.3.3 Proposed Subpart C: Integrated Steelmaking

The 1982 iron and steel regulation included separate subcategories for steelmaking, vacuum degassing, continuous casting, and hot forming. In 2000, EPA proposed a revised subcategorization structure that recognized the differences between integrated and non-integrated steelmaking facilities. The Agency proposed segregating steelmaking operations at integrated plants and non-integrated plants to simplify the structure of the regulation and because different wastewater generation rates were observed between integrated and non-integrated plants. This proposed structure included combining certain operations at integrated facilities from the existing steelmaking, vacuum degassing, and continuous casting operations into an “integrated steelmaking subcategory.” The following provides a general description of each of these operations.

BOFs are one of two types of furnaces used in steelmaking in the United States². They are typically used for high tonnage production of carbon steels at integrated mills. Integrated steel mills use BOFs to refine a metallic charge consisting of approximately two-thirds molten iron and one-third steel scrap. Facilities use three types of air pollution control systems to treat furnace off-gases from BOF steelmaking operations: semi-wet air pollution controls, wet-open combustion air pollution controls, and wet-suppressed combustion air pollution controls. Each type of air pollution control system operates in a different manner and generates different wastewater flow rates. However, the wastewater characteristics are similar. Twenty-four BOF shops are operated at 20 integrated steel plants and one non-integrated steel plant. Of the 24 BOF shops, eight use semi-wet air pollution control systems, eight use wet-open combustion air pollution control systems, seven use wet-suppressed combustion air pollution control systems, and one uses a combination wet-open/wet-suppressed combustion air pollution control system.

Vacuum degassing is a batch process where molten steel is subjected to a vacuum for composition control, temperature control, deoxidation, degassing, decarburization, and the removal of impurities from the steel. Oxygen and hydrogen are the principal gases removed

²The other type is an electric arc furnace (EAF), which is typically used to produce low-tonnage carbon, alloy, and stainless steels at non-integrated mills.

from the steel. In most degassing systems, the vacuum is provided by barometric condensers; thus, direct contact between the gases and the barometric water occurs.

Likewise, ladle metallurgy is also a batch process where molten steel is refined in addition to, or in place of, vacuum degassing. These operations include argon bubbling, argon-oxygen decarburization (AOD), electroslag remelting (ESR), and lance injection. These additional refining operations do not generate any process water.

Casting is generally a continuous process where molten steel is shaped while cooling into semi-finished shapes after the vacuum degassing and/or ladle metallurgy processes. The continuous casting machine includes a receiving vessel for molten steel, water-cooled molds, secondary cooling water sprays, containment rolls, oxygen-acetylene torches for cutoff, and a runout table. Wastewater is generated by a direct contact water system used for spray cooling and for flume flushing to transport scale from below the caster runout table. The other main casting operation type is ingot casting, in which molten steel is poured into ingot molds.

Under the proposed structure, wastewaters from basic oxygen furnace operations were included with wastewaters from vacuum degassing operations and continuous casting operations to make up the “integrated steelmaking subcategory.” Hot forming operations that took place either at integrated mills or were not associated directly with steelmaking operations were to be covered by the “integrated and stand-alone hot forming subcategory.” Wastewaters from electric arc furnaces were included with wastewaters from vacuum degassing operations, continuous casting operations and hot forming operations to make up the “non-integrated steelmaking and hot forming subcategory.” This proposed subcategory is discussed in more detail in Section 6.3.5 below.

After considering comments to the proposal and conducting a thorough re-evaluation of the costs, pollutant reductions, and economic achievability of the proposed subcategorization structure, EPA, for the most part, is not promulgating new effluent limitations guidelines and standards for the proposed “integrated steelmaking subcategory.” (EPA is promulgating a provision for one segment whereby permit writers or pretreatment control authorities can establish alternative limitations on a best professional judgement basis.) Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, this final rule maintains the current subcategorization structure in regards to steelmaking, vacuum degassing, and continuous casting.

However, EPA is revising the segments of the 1982 steelmaking subcategory so that they cover the following operations:

- Electric arc furnace steelmaking - semi-wet;
- BOF steelmaking - wet-suppressed combustion (retained);

- BOF steelmaking - wet-open combustion, and electric arc furnace steelmaking-wet; and
- BOF steelmaking - semi-wet.

6.3.4 Proposed Subpart D: Integrated and Stand-Alone Hot Forming

Hot forming is a process that heats ingots, blooms, billets, slabs, or rounds to rolling temperatures so that the products will form under mechanical pressure into semi-finished shapes for further hot or cold rolling or as finished shapes. Process water is used for scale breaking, flume flushing, and direct contact cooling.

Integrated and stand-alone hot forming operations include hot forming processes at integrated steel plants and stand-alone hot forming mills. Four different types of hot forming mills are operated at integrated and stand-alone facilities: flat mills (hot strip and sheet mills and plate mills), primary mills (slabbing and blooming mills), section mills (bar and rod mills), and hot formed pipe and tube mills. The existing regulation segregates the hot forming subcategory into four different segments based on differences in flow rates: primary mills, section mills, flat mills, and pipe and tube mills.

The proposed integrated and stand-alone hot forming subcategory includes hot forming processes that takes place at integrated mills or at locations that were not associated directly with steelmaking operations (stand-alone hot forming mills). EPA proposed two segments, carbon and alloy steel and stainless steel, for this subcategory because of differences in pollutants present in the wastewater and because facilities typically combine these types of wastewaters together for treatment.

However, for today's final rule, EPA has not adopted limits and standards for the proposed "integrated and stand-alone hot forming subcategory." Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, the final rule maintains the existing hot forming subcategory.

6.3.5 Proposed Subpart E: Non-Integrated Steelmaking and Hot Forming

As explained in Section 6.3.3 above, in 2000, EPA proposed a revised subcategorization structure that recognized the differences between integrated and non-integrated steelmaking facilities. The Agency proposed segregating steelmaking operations at integrated plants and non-integrated plants to simplify the structure of the regulation and because different wastewater generation rates were observed between integrated and non-integrated plants. This proposed structure included combining certain operations at non-integrated facilities from the existing steelmaking, vacuum degassing, continuous casting, and hot forming subcategories into a "non-integrated steelmaking and hot forming subcategory." The following provides a general description of non-integrated steelmaking. Section 6.6.3 provides descriptions of the other operations included in this subcategory.

Non-integrated steelmaking in this proposed subcategory is achieved with the use of electric arc furnaces (EAF). EAFs melt and refine a metallic charge of scrap steel to produce low tonnage carbon, alloy, and stainless steels at non-integrated mills. In addition, most mills operate EAFs with dry air cleaning systems, which produce no process wastewater discharges. There are a small number of wet and semi-wet systems.

Departing from the structure of the 1982 regulation, EPA proposed the non-integrated steelmaking and hot forming subcategory as a means to simplify the regulatory structure by grouping the basic steelmaking (electric arc furnace, vacuum degassing, and continuous casting) and forming operations performed at non-integrated plants under one subcategory. EPA proposed to combine these operations into one subcategory because of similar wastewater pollutant characteristics and the potential for cotreatment of these wastewaters. Substantially lower wastewater flow rates are demonstrated at non-integrated facilities, due to their lower water application rates, use of high-rate water recycle systems, and good water management practices.

As in the integrated and stand-alone hot forming subcategory, EPA proposed two segments, carbon and alloy steel and stainless steel, in this subcategory due to differences in wastewater pollutant characteristics. The Agency believed this approach would be helpful in simplifying the existing regulation was appropriate because of the similar wastewater characteristics, demonstrated flows, and treatment systems applied at these mills. For additional details of the proposed subcategorization structure and rational, see Section 6 of the Development Document for the Proposed Iron and Steel Manufacturing Point Source Category, EPA 831-B-00-011, December 2000.

For today's final rule, EPA has not adopted limits and standards for the proposed "non-integrated steelmaking and hot forming subcategory." Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, the final rule maintains the existing subcategorization structure in regards to steelmaking, vacuum degassing, and continuous casting.

6.3.6 Proposed Subpart F: Steel Finishing

Since extensive cotreatment of steel finishing wastewaters is currently practiced by the industry, the Agency proposed to simplify the regulatory structure for steel finishing operations by combining them into a single subcategory, steel finishing, because of the compatibility of wastewaters for treatment. The proposed steel finishing subcategory included salt bath and ESS descaling, acid pickling, cold forming, alkaline cleaning, continuous annealing, hot coating, and electroplating at integrated, non-integrated, and stand-alone facilities. EPA proposed to divide this subcategory into carbon and alloy steel and stainless steel segments to reflect variations in the wastewater pollutant characteristics and flow rates. The following provides a general description of the operations included in the proposed steel finishing subcategory and additional information on the proposed structure and EPA's rational is located in

Section 6 of the Development Document for the Proposed Iron and Steel Manufacturing Point Source Category, EPA 831-B-00-011, December 2000.

Salt bath descaling is the oxidizing and reducing using molten salt baths to remove heavy scale from specialty and high-alloy steels. Process wastewaters originate from quenching and rinsing operations conducted after processing in the molten salt baths. Electrolytic sodium sulfate (ESS) descaling is performed on stainless steels for essentially the same purposes as salt bath descaling.

Acid pickling is the use of acid solutions of various acids to remove oxide scale from the surfaces of semi-finished products prior to further processing by cold rolling, cold drawing, and subsequent cleaning and coating operations. Process wastewaters include spent pickling acids, rinse waters, and pickling line fume scrubber water.

Cold forming is the shaping of metal products conducted on hot rolled and pickled steels at ambient temperatures to impart desired mechanical and surface properties in the steel. Process wastewater characteristics result from using synthetic or animal-fat based rolling solutions, many of which are proprietary.

Hot coating is a process where pre-cleaned steel is immersed into baths of molten metal. Hot coating is typically used to improve resistance to corrosion, and for some products, to improve appearance and ability to hold paint. Wastewaters result principally from cleaning operations prior to the molten bath.

For today's final rule, EPA has not adopted limits and standards for the proposed "steel finishing subcategory." Therefore, EPA is not adopting the proposed subcategorization structure. Changing the subcategorization structure only made sense when EPA believed it would promulgate new limits and standards for the new subcategory. Consequently, the final rule maintains the existing subcategorization structure in regards to salt bath descaling, acid pickling, cold forming, alkaline cleaning, and hot coating.

6.3.7 Proposed Subpart G: Other Operations

In 2000, EPA proposed to create a new subcategory, the "other operations subcategory," which included the following operations: direct-reduced ironmaking, forging, and briquetting. These manufacturing operations are not covered by the existing rule, but are directly related to iron and steel production and are performed at iron and steel sites.

The direct-reduced ironmaking (DRI) process produces relatively pure iron by reducing iron ore in a furnace below the melting point of the iron produced. DRI is used as a substitute for scrap steel in the non-integrated steelmaking process to minimize contaminant levels in the melted steel and to allow economic steel production when market prices for scrap are high. Process wastewaters are generated from air pollution control devices, but contain insignificant toxic pollutants.

The briquetting process of agglomeration forms materials into discrete shapes of sufficient size, strength, and weight so that the material can serve as feed for subsequent processes. Briquetting does not generate process wastewater.

Forging is a hot forming operation in which a metal piece is shaped by hammering or by processing in a hydraulic press. Process wastewaters are generated from direct contact cooling water, but contain insignificant toxic pollutants.

As explained in its proposal, the Agency determined that it was appropriate to segment this subcategory on the basis of manufacturing operation. Therefore, the Agency proposed to segment the subcategory into DRI, forging and briquetting.

The Agency received no comments on the proposed subcategorization structure and determined it was appropriate to establish limits for this subcategory. Consequently, the final rule includes this additional subcategory for “other operations.”

Table 6-1**Subcategory Comparison of the 1982 and Proposed Regulations**

| 1982 Regulation | Proposed Regulation | | |
|------------------------|---|---|--|
| A. Cokemaking | A. Cokemaking | | |
| B. Sintering | B. Ironmaking | | |
| C. Ironmaking | | | |
| D. Steelmaking | C. Integrated Steelmaking | E. Non-Integrated Steelmaking and Hot Forming | |
| E. Vacuum Degassing | | | |
| F. Continuous Casting | | | |
| G. Hot Forming | D. Integrated and Stand-Alone Hot Forming | | |
| H. Salt Bath Descaling | F. Steel Finishing | | |
| I. Acid Pickling | | | |
| J. Cold Forming | | | |
| K. Alkaline Cleaning | | | |
| L. Hot Coating | | | |
| | G. Other Operations | | |

Table 6-2**Final Subcategorization**

| Subcategory | | Segment | Manufacturing Process |
|--------------------|--------------------|---------------------------|---|
| A | Cokemaking | By-Product Recovery | --- |
| | | Non-Recovery | --- |
| B | Sintering | Dry Air Pollution Control | --- |
| | | Wet Air Pollution Control | --- |
| C | Ironmaking | Iron Blast Furnace | --- |
| D | Steelmaking | Basic Oxygen Furnace | Semi-Wet |
| | | | Wet-Suppressed Combustion |
| | | | Wet-Open Combustion |
| | | Electric Arc Furnace | Semi-Wet |
| | | | Wet |
| E | Vacuum Degassing | --- | --- |
| F | Continuous Casting | --- | --- |
| G | Hot Forming | Primary | Carbon and Specialty Mills Without Scarfers |
| | | | Carbon and Specialty Mills With Scarfers |
| | | Section | Carbon Mills |
| | | | Specialty Mills |
| | | Flat | Hot Strip and Sheet Mills |
| | | | Carbon Plate Mills |
| | | | Specialty Plate Mills |
| | | Pipe & Tube Mills | --- |

Table 6-2 (Continued)

| Subcategory | | Segment | Manufacturing Process |
|-------------|---------------------|-------------------|----------------------------------|
| H | Salt Bath Descaling | Oxidizing | Batch: Sheet, Plate |
| | | | Batch: Rod, Wire, Bar |
| | | | Batch: Pipe, Tube |
| | | | Continuous |
| | | Reducing | Batch |
| | | | Continuous |
| I | Acid Pickling | Sulfuric Acid | Rod, Wire, Coil |
| | | | Bar, Billet, Bloom |
| | | | Strip, Sheet, Plate |
| | | | Pipe, Tube, Other |
| | | | Fume Scrubber |
| | | Hydrochloric Acid | Rod, Wire, Coil |
| | | | Strip, Sheet, Plate |
| | | | Pipe, Tube, Other |
| | | | Fume Scrubber |
| | | | Acid Regeneration |
| | | Combination Acid | Rod, Wire, Coil |
| | | | Bar, Billet, Bloom |
| | | | Strip, Sheet, Plate - Continuous |
| | | | Strip, Sheet, Plate - Batch |
| | | | Pipe, Tube, Other |
| | | | Fume Scrubber |

Table 6-2 (Continued)

| Subcategory | | Segment | Manufacturing Process |
|-------------|-------------------|---|--|
| J | Cold Forming | Cold Rolling | Recirculation: Single Stand |
| | | | Recirculation: Multi Stand |
| | | | Combination |
| | | | Direct Application: Single Stand |
| | | | Direct Application: Multi Stand |
| | | Cold Worked Pipe & Tube | Water Solutions |
| | | | Oil Solutions |
| K | Alkaline Cleaning | Batch | --- |
| | | Continuous | --- |
| L | Hot Coating | Galvanizing, Terne and Other Metal Coatings | Strip, Sheet, and Miscellaneous Products |
| | | | Wire Products and Fasteners |
| | | Fume Scrubbers | --- |
| M | Other Operations | Direct Iron Reduction | --- |
| | | Forging | --- |
| | | Briquetting | --- |

SECTION 7

WASTEWATER CHARACTERIZATION

This section presents information on water use and wastewater generation practices associated with iron and steel manufacturing operations, identifies pollutants of concern (POCs), and presents untreated process wastewater characterization data for the POCs. Section 7.1 presents water use, wastewater sources, wastewater generation rates, and wastewater discharge practices for the seven operations that EPA had proposed as subcategories. (Although EPA did not adopt a new subcategorization scheme as proposed, EPA is using that structure in this section to facilitate comparison to the proposal.) Section 7.2 describes EPA's methodology for selecting POCs and identifies the POCs that EPA had considered for each proposed subcategory and segment. Section 7.3 presents untreated process wastewater characterization data collected during EPA's sampling program for the POCs, to the extent that it does not disclose confidential business information. Section 7.4 presents references used in this section.

7.1 Water Use and Wastewater Generation and Discharge

The principal uses of process water by iron and steel manufacturing processes include cooling and cleaning of process off-gases, direct cooling of coke and slag, direct cooling and cleaning of steel, product rinsing, process solution makeup, and direct cooling of process equipment. Most of the water used by the iron and steel industry is for non-contact cooling of processing equipment. Water is also used for steam and power generation.

Process wastewaters are any wastewaters that come into direct contact with the process, product, by-products, or raw materials for the manufacturing of iron and steel. Process wastewaters also include wastewater from slag quenching, equipment cleaning, air pollution control devices, rinse water, and contaminated cooling water. Sanitary wastewater and storm water are not considered process wastewaters. Non-contact cooling wastewaters are cooling waters that do not directly contact the processes, products, by-products, or raw materials; these wastewaters are not considered process wastewaters. Non-process wastewaters are those generated by non-process operations such as utility wastewaters (water treatment residuals, boiler blowdown, air pollution control wastewaters from heat recovery equipment, and water generated from co-generation facilities), treated or untreated wastewaters from ground water remediation systems, dewatering water for building foundations, and other wastewater streams not associated with production processes.

In this section, the term wastewater discharge flow rates refers to the volume of wastewater that is generated and then discharged by individual process operations; the wastewater discharge flow rate does not include the volume of wastewater that is recycled back to the process. For example, many iron and steel operations such as hot forming include high-rate recycle water systems where the vast majority of water is recirculated, while the relatively small blowdown stream is routed to wastewater treatment. In this example, the blowdown stream comprises the wastewater discharged from this process. EPA provides the wastewater discharge flow rates in this section for several reasons. First, because the rule is mass-based,

both the wastewater discharge rate and the effluent concentration are important components to determine compliance. Second, wastewater discharge flow rates provide information to permit writers to better understand water use and discharge practices by the iron and steel industry, and to iron and steel site personnel to identify opportunities for water conservation at their facilities.

This document generally presents wastewater flow ranges and medians based on the data reported by the iron and steel industry in response to the industry survey. EPA analyzed the reported flow rates to determine process water flows at each site and used these data to calculate ranges and medians. EPA identified and resolved discrepancies in reported process water flows wherever possible by performing water flow balances from all data reported in the questionnaire and by contacting site personnel. EPA presents median flow rates in this section instead of mean flow rates because the median better represents typical operation of water systems because the median is not influenced as much as the mean by extremely high flow rates. Presenting median flow rates also allows EPA to reveal as much information as possible without compromising confidential business information.

The following subsections further describe process water use, process wastewater sources, and process wastewater discharge flow rates for each proposed iron and steel subcategory. Non-contact cooling water, sanitary water, storm water, and non-process waters are not further discussed. Table 7-1 provides EPA's estimates for the annual process wastewater discharge rate by operation and discharge type (direct or indirect) and the number of zero or alternative dischargers for each operation. The estimates provided below are based on data collected in the U.S. EPA Collection of 1997 Iron and Steel Industry Data (EPA Survey).

7.1.1 Cokemaking Operations

The cokemaking subcategory covers the by-product recovery and non-recovery cokemaking segments. The water use and wastewater generation sources for cokemaking operations are described below.

Water Use

Both types of cokemaking operations use large volumes of water for coke quenching; the water application rates required for quenching are balanced between the need to quench the incandescent coke, and the need to leave enough heat in the coke to evaporate water trapped within it. Water used for coke quenching is typically plant service water (i.e., the plant's water supply), non-contact cooling water, or treated coke plant wastewater. The Agency does not advocate quenching coke with untreated wastewater because of the potential for air pollution and ground water contamination associated with this practice. To the Agency's knowledge, coke quenching with untreated process wastewaters is no longer practiced at any of the coke plants that responded to the industry survey. Since all U.S. coke plants recycle and evaporate coke quench water, a minimum amount of wastewater is generated from coke quenching operations. Excess coke quenching water is a reported wastewater source at two by-product recovery plants. Standard industry practice is to recycle coke quenching water to extinction; adequate controls can eliminate process wastewater discharges from coke quenching.

Several by-product recovery cokemaking facilities also use plant service water for wet air pollution control (WAPC) of cokemaking processes such as larry coal car charging, coke pushing, by-product recovery, and coke handling, crushing, and blending. WAPC water is typically recirculated. Other water uses in the by-product recovery cokemaking process include coke oven gas cooling and steam heating.

Process Wastewater Sources for By-Product Recovery Cokemaking

By-product recovery cokemaking operations generate wastewater from a number of sources. The greatest volume of wastewater generated at by-product recovery plants is waste ammonia liquor. Ammonia liquor is used to scrub coke oven gas to condense tars and moisture and is recycled at a high rate. Excess or waste ammonia liquor, comprising coal moisture and volatile compounds released from the coal during the coking process, is removed and sent to treatment. Waste ammonia liquor has high concentrations of ammonia, cyanide, sulfide, benzene, and phenols (Reference 7-1). Waste ammonia liquor flow rates reported in response to the survey range from 26 gallons per ton (gpt) to 270 gpt, with a median flow rate of 69 gpt. These flow rates are higher than would be expected based on a conservation of mass analysis of coal moisture and a comparison to the values reported for the 1982 rulemaking effort. Therefore, EPA concludes that the reported flow rates include a combination of wastewaters from other sources. Section 13.3.1 describes waste ammonia liquor flow rates in more detail and provides the basis of EPA's conclusion that a representative waste ammonia liquor flow rate is approximately 36 gpt.

Nearly all by-product recovery plants reported one or more other sources of wastewater, which are commingled with excess ammonia liquor for subsequent treatment. These wastewater sources include the following:

- Coke oven gas desulfurization;
- Crude light oil recovery;
- Ammonia still operation;
- Coke oven gas condensates;
- Final gas coolers;
- Barometric condensers;
- National emission standards for hazardous air pollutants (NESHAP) controls for benzene;
- WAPC devices; and
- Other miscellaneous process wastewater.

Below are detailed descriptions of these wastewater sources and wastewater discharge flow rates as reported in response to the industry survey. Note that, although the reported flow rates represent the sites' best estimates of source-specific discharge flow rates, EPA identified inconsistencies in reported wastewater discharge flow rate data from coke plants that EPA could not resolve. The data reported herein reflect what was reported by the industry in the questionnaires.

Approximately 40 percent of by-product recovery plants reported operating coke oven gas desulfurization systems that generate process wastewater. Desulfurization wastewater is composed of condensed moisture in the gas stream, and wastewater discharge flow rates reported in response to the survey range from <1 gpt to 55 gpt, with a median discharge flow rate of 13 gpt.

Approximately 70 percent of by-product recovery plants reported generating wastewater from crude light oil recovery operations. Distillates from the wash oil still and subsequent separation equipment are condensed and decanted to recover oil by-products. Condensates removed from product decanters comprise the crude light oil recovery wastewater stream. Wastewater discharge flow rates vary depending on the degree of separation and recovery (crude or refined), and the extent of wastewater recirculation. Reported wastewater discharge flow rates range from approximately 3 gpt to 71 gpt, with a median discharge flow rate of 20 gpt.

Steam used for operation of ammonia stills condenses and adds to the volume of the still effluent. The volume of steam can be minimized through use of heat exchangers on the still effluent. Most ammonia stills are operated with caustic addition for pH control, while some are operated with lime or soda ash. Solutions of these chemicals also add to the discharge flow. Twelve sites reported wastewater flow from the ammonia stills; reported wastewater discharge flow rates range from 0.03 gpt to 87 gpt, with a median discharge flow rate of 9 gpt.

Coke oven gas condensates are generated by a variety of gas cooling and by-product recovery operations. While some sites reported coke oven gas condensates as a component of their reported wastewater ammonia liquor discharge flow rates, or as specific by-product recovery discharge flow rates, others reported coke oven gas condensate discharge flow rates separately. Reported coke oven gas condensate discharge flow rates ranged from <1 gpt to 15 gpt, with a median discharge flow rate of 1.5 gpt.

Final gas coolers generate wastewater from direct contact cooling coke oven gas with water sprays that dissolve any remaining soluble gas components and physically flush out condensed naphthalene crystals. Only one of the surveyed by-product recovery plants specifically reported final gas cooler discharge flow rates separately from other reported wastewater flow rates (e.g., waste ammonia liquor or coke oven gas condensates). This plant reported a final cooler blowdown rate of 12 gpt. EPA estimates that typical final cooler wastewater volumes range from 2 gpt to 12 gpt based on wastewater discharge flow data collected from this site and from data collected for development of the 1982 regulation (Reference 7-1).

Some plants use vacuum crystallizers to form and remove ammonia sulfate crystals. Barometric condensers are used to create a vacuum in the crystallizer systems, which results in the generation of condensate wastewater. None of the surveyed by-product recovery plants specifically reported barometric condenser discharge flow rates separately from other reported wastewater flow rates; however, approximately 60 percent of by-product recovery plants reported recovery of ammonium sulfate. Two plants reported generating ammonia recovery wastewater, and one plant reported generating blowdown from the saturator/crystallizer, which may or may not include barometric condenser wastewater. EPA estimates that typical barometric condenser wastewater volumes range from 1 gpt to 18 gpt based on wastewater discharge flow data collected from these sites and data collected for development of the 1982 regulation (Reference 7-1).

Approximately 20 percent of by-product recovery plants reported generating wastewater from NESHAP control systems for benzene emissions at by-product recovery plants. NESHAP controls are site-specific and are designed to minimize emissions during cokemaking and by-product recovery. An example of a NESHAP control system that generates wastewater is water seals on storage and process tanks, although most plants use gas blanketing. Reported NESHAP wastewater discharge flow rates cannot be disclosed to prevent compromising confidential business information.

Approximately 50 percent of by-product recovery plants reported generating wastewater from WAPC devices used to control emissions from operations such as coal charging, coke pushing, by-product recovery, and coal drying. Wastewater from WAPC devices may contain high concentrations of suspended solids (Reference 7-1). WAPC water is typically recirculated, with the system blowdown comprising the wastewater stream. Standard industry practice is to dispose of WAPC wastewater from coal charging and coke pushing by coke quenching. The Agency supports this practice because these types of WAPC wastewater do not contain volatile pollutants found in waste ammonia liquor and other untreated wastewaters and would not result in transfer of these pollutants to the atmosphere. Reported coke pushing WAPC wastewater discharge flow rates ranged from 1.2 gpt to 119 gpt, with a median discharge flow rate of 27 gpt (the flow rates include water being used for coke quenching). Relatively few by-product recovery plants perform WAPC of emissions from by-product recovery and coal drying; WAPC wastewaters generated by these operations are routed to wastewater treatment.

Approximately 40 percent of by-product recovery plants reported generating miscellaneous wastewaters. Reported wastewater sources were site-specific and discharge flow rates ranged from <1 gpt to 72 gpt, with a median discharge flow rate of 12 gpt. Examples of reported wastewater sources include: ovens basement, furnace condensate, tar storage drainage, coal yard drainage, exhauster and flare stack seals, floor drains, drip legs, and lab sink waste. In addition to these sources, approximately 25 percent of plants reported generating small volumes (<1 gpt) of equipment cleaning and washdown water. Many sites have improved their collection of miscellaneous wastewaters since the promulgation of the 1982 regulation. The Agency believes that collecting and treating these wastewaters prior to discharge is necessary to ensure compliance with the regulation.

In summary, by-product recovery cokemaking plants generate process wastewater from a variety of sources. Reported total plant process wastewater discharge flow rates ranged from 55 gpt to 281 gpt, with a median discharge flow rate of 118 gpt. These reported flow rates include the process wastewater sources described above, but exclude other wastewater sources that may be commingled with process wastewater for treatment, such as contaminated ground water, control water for subsequent biological treatment, WAPC water suitable for coke quenching, and cooling tower blowdown. WAPC water used for coke quenching is also not included in the discharge flow rate.

Process Wastewater Sources for Non-Recovery Cokemaking

Non-recovery cokemaking operations do not generate process wastewater. Process area storm water and boiler blowdown, which are typically disposed of by coke quenching at non-recovery facilities, are not considered process waters. In addition, EPA does not consider wastewater associated with waste heat recovery and reuse from co-generation facilities, such as WAPC wastewater, boiler blowdown and cooling tower blowdown to be process wastewater subject to this rule.

7.1.2 Sintering and Ironmaking Operations

Separate discussions are provided below for sintering and blast furnace ironmaking segments of the proposed ironmaking subcategory. In the final rule, these operations continue to be regulated in separate subcategories.

Sintering

The sintering process primarily uses water to add to the sinter mix to attain the desired moisture content. The typical water source is plant service water, which is also used by most plants as makeup water for WAPC of sintering processes such as the sintering stand windbox and material processing. Other water uses are site-specific and include sinter cooling, belt sprays, and equipment cleaning and washdown.

The primary wastewater source for sintering operations is WAPC system wastewater. Seven sites reported in their survey response that they used WAPC systems to control air emissions from the sintering process, while two sites used dry air pollution control (DAPC) systems. WAPC wastewater is recirculated, and the system blowdown is discharged. All of the sinter plants generating process wastewater reported using wet scrubbers to control wind box emissions, and some sites also reported using scrubbers to control emissions at the discharge end of the sinter strand. Reported WAPC wastewater discharge flow rates ranged from 0 gpt to 452 gpt, with a median discharge flow rate of 73 gpt. Sites that use dry air pollution control do not generate process wastewater.

Facilities identified other sources of sintering wastewater in the industry surveys, including sinter cooling water, belt sprays, and equipment cleaning water. EPA believes that

these miscellaneous wastewaters are discharged with the WAPC blowdown because the survey respondents did not provide flow rate data for these sources.

Blast Furnace Ironmaking

Blast furnace ironmaking primarily uses water in wet gas cleaning and cooling systems designed to clean and cool the furnace off-gas prior to its use as a fuel in the blast furnace stoves. Water is recirculated at a high rate. Other water uses include water addition to adjust the moisture content of the burden, slag quenching, and gas seals. Source water may be provided by plant service water, but often consists of treated blast furnace wastewater, other process wastewater, slag quench wastewater, or gas seal wastewater.

Blowdown from the high-energy scrubbers and gas coolers is the primary wastewater from blast furnace ironmaking. Reported gas cleaning system wastewater discharge flow rates ranged from 1.5 gpt to 2,182 gpt, with a median discharge flow rate of 15 gpt. Blast furnace gas seal wastewater is also a significant wastewater source; however, common industry practice is to reuse blast furnace gas seal wastewater as makeup for the gas cleaning system. Among survey respondents that reported separate gas seal wastewater discharge flow rates, flow rates ranged from <1 gpt to 156 gpt, with a median discharge flow rate of 15 gpt.

Pump seals, blast furnace drip legs, equipment cleaning water, and excess slag quenching wastewater are other, relatively minor sources of process wastewater. Common industry practice is to reuse these wastewater streams as makeup for the gas cleaning system.

Five sites achieve zero discharge and five sites achieve reduced discharge of blast furnace wastewater by using all or a portion of the gas cleaning blowdown for slag quenching. One additional site achieves zero discharge by discharging gas cleaning blowdown to one unlined and one synthetically lined pond where the wastewater infiltrates and evaporates. The Agency does not advocate using untreated gas cleaning blowdown for slag quenching in unlined slag pits because of the potential for ground water contamination and air pollution associated with this practice.

7.1.3 Integrated Steelmaking Operations

Separate discussions are provided below for the following manufacturing processes within the integrated steelmaking subcategory that EPA had proposed: basic oxygen furnace steelmaking, ladle metallurgy, vacuum degassing, and continuous casting.

Six of 20 integrated steelmaking sites operate combined wastewater treatment and/or recycle systems for vacuum degassing, continuous casting, and/or hot forming operations. The common characteristics of the process wastewater from each of these operations allow the sites to commingle and treat the wastewater simultaneously.

Basic Oxygen Furnace (BOF) Steelmaking

The primary use of water and primary source of wastewater in BOF steelmaking are air pollution control systems designed to treat furnace off-gases prior to release into the atmosphere. Each BOF shop uses one of three types of WAPC systems: semi-wet, wet-suppressed combustion, or wet-open combustion (one shop uses a combination of WAPC systems). Semi-wet systems apply water to the furnace off-gases to partially cool and condition the off-gases prior to particulate removal in an electrostatic precipitator. Both wet-suppressed and wet-open systems use wet scrubbers for gas cooling and conditioning and for particulate removal. Wet-suppressed systems are high-energy wet scrubbing systems that limit excess air entering the furnace mouth, minimizing carbon monoxide combustion and thus minimizing the volume of gas requiring treatment. Wet-open systems are gas cleaning systems that admit excess air to allow the combustion of carbon monoxide prior to high-energy scrubbing. Plant service water is the predominant water source for all three system types. Other minor wastewater sources are site-specific and include excess slag quench water, hood cooling water losses, cooling tower blowdown, and equipment cleaning water.

EPA analyzed BOF steelmaking wastewater discharge flow rates based on the type of WAPC system used because of differences in water recycle rates and wastewater discharge rates. Eight of the 24 BOF shops active in 1997 operated semi-wet air pollution control systems. Reported wastewater discharge flow rates ranged from 0 gpt to 124 gpt, with a median discharge flow rate of 22 gpt. Wastewater is generally not recirculated. Two BOF shops reported zero discharge of process wastewater, while two additional BOF sites reported discharge rates of <6 gpt. Sites achieve zero or relatively low discharges from semi-wet systems by balancing the applied water with water that evaporates in the conditioning process. Although the 1982 regulation designates semi-wet air pollution control as zero discharge (Reference 7-1), currently not all of the sites are able to achieve this discharge status because of safety considerations and because the level of control required to attain zero discharge is difficult to maintain at all times. Some sites operate their semi-wet systems with excess water, which is subsequently discharged, to flush the air pollution control ductwork and prevent the buildup of debris within the ductwork. If this wet debris accumulates, it has the potential to fall back into the BOF, causing explosions and process upsets. The Agency recognizes the benefits of using excess water in these systems.

Seven BOF shops operate wet-suppressed combustion air pollution control systems. All of the shops recirculate air pollution control wastewater at a high rate. Reported wastewater discharge flow rates ranged from 14 gpt to 97 gpt, with a median discharge flow rate of 34 gpt. Five of these BOF shops use carbon dioxide injection in the high-rate recycle system to reduce wastewater blowdown requirements. Carbon dioxide injection allows carbonates to precipitate in the treatment system clarifiers (in effect water softening), thus minimizing the need for blowdown from the system.

Eight BOF shops (at seven sites) operate wet-open combustion air pollution control systems. All of the shops recirculate air pollution control wastewater at a high rate. Reported wastewater discharge flow rates ranged from 0 gpt to 201 gpt, with a median discharge

flow rate of 95 gpt. One shop achieves zero discharge of process wastewater by using carbon dioxide injection, which eliminates the need for system blowdown because 100 percent of the water is recirculated. Two additional shops achieve wastewater discharge flow rates less than the median rate by using carbon dioxide injection to reduce system blowdown requirements.

Ladle Metallurgy

None of the estimated 103 sites that conduct ladle metallurgy operations reported generating or discharging process wastewater from these operations. Water is used and discharged by vacuum degassers that often operate as part of ladle metallurgy stations. Water use and wastewater discharge by vacuum degassing is discussed below.

Vacuum Degassing

The vacuum generating system is the primary use of water and primary source of wastewater in vacuum degassing systems. Steam ejectors create a vacuum in vacuum degassing systems; condensate wastewater is generated from this process. Molten steel exhaust comes in contact with the injected steam, thereby contaminating the condensate wastewater. Wastewater is recirculated at a high rate; blowdown is the vacuum degassing wastewater stream. Makeup water for the system is generally plant service water. Reported wastewater discharge flow rates ranged from 0 gpt to 735 gpt, with a median discharge flow rate of 44 gpt. No other sources of wastewater were reported.

Continuous Casting

The primary use of water and primary source of wastewater in continuous casting are direct contact spray cooling (secondary cooling) of the partially solidified product as it exits the mold to produce a solid product. (Primary cooling and equipment cooling are non-contact cooling systems, which are not discussed in this section.) As the cast product surface oxidizes, scale is washed away by the cooling water. The spray water also becomes contaminated with oils and greases that are released by hydraulic and lubrication systems. Wastewater is recirculated at a high rate; blowdown comprises the continuous casting wastewater stream. Makeup water for the system is generally plant service water; however, some sites also use non-contact cooling water or treated process wastewater. Reported continuous caster wastewater discharge flow rates ranged from 1 gpt to 1,836 gpt, with a median discharge flow rate of 35 gpt.

Another use of water and source of wastewater is flume flushing. As the cast product is placed on the run-out tables for final cooling, additional scale flakes off and drops beneath the tables. Some sites sluice this scale to the spray cooling water pit. Reported flume flushing wastewater discharge rates cannot be disclosed to prevent compromising confidential business information. Other minor wastewater sources were site-specific and include equipment cleaning water, torch table wastewater, and granulator water.

Non-process wastewater sources often treated with process wastewater include low-volume losses from closed caster mold and machine cooling water systems.

7.1.4 Integrated and Stand-Alone Hot Forming Operations

EPA identified contact water systems used for scale removal, roll and machinery cooling, product cooling, flume flushing, and other miscellaneous uses during the hot forming process as the primary use of water and primary wastewater source. EPA uses contact water systems as a generic term because there are many different sources of contact water within a hot forming mill. Sites may have multiple hot forming contact water systems.

Certain contact wastewaters are common to all hot forming operations, regardless of mill type (i.e., primary, section, flat, and pipe and tube). When the hot steel product is being rolled, iron oxide scale forms on the surface of the hot steel. The scale is removed by direct contact high-pressure sprays (gauge pressure of approximately 1,000 - 2,000 pounds per square inch) that release water before each roll pass of the product. Low-pressure spray cooling water is used to prevent the mill stand rolls and the table rolls from overheating as the hot steel passes over or in between them. Scale removal and cooling wastewater are discharged beneath the rolling mill to trenches called flumes. Sites sluice this scale (flume flushing wastewater) to the scale pits.

Hot strip mills use large quantities of direct contact water, referred to as laminar flow, to cool the strip on the run-out table after it has been rolled on the final mill finishing stands. Laminar flow is a method in which a nonturbulent water flow is applied over the entire surface of the strip to effect uniform surface cooling and to prevent strip distortion. This water is relatively clean and is often recycled because of its large volume. In addition, low-pressure spray is also applied at the downcoiler to allow proper strip coiling.

Makeup water for contact water systems is generally plant service water; however, many sites also use non-contact cooling water or treated process wastewater. At most facilities that discharge direct contact wastewater (30 of 38), wastewater is recirculated at a high rate, and system blowdown is the resulting wastewater stream requiring treatment. However, some mills operate multiple contact water systems (e.g., nonlaminar and laminar cooling) and not all systems are recirculating. In addition, some facilities operate multiple hot forming mills, but not all mills recirculate contact wastewater. Other miscellaneous, low-volume wastewater sources reported by a significant number of facilities include wastewater collected in basement sumps, roll shop wastewater, and equipment cleaning and washdown wastewater. The range of and median wastewater discharge flow rates for wastewaters generated by hot forming operations at integrated and stand-alone hot forming sites are listed below.

| Wastewater Source | Range of Discharge Flow Rates (gpt) | Median Discharge Flow Rate (gpt) |
|--|--|---|
| Contact wastewater | 0 to 17,299 | 231 |
| Basement sumps | 0 to 108 | 4 |
| Roll shop wastewater | 0 to 21 | 0.01 |
| Equipment cleaning and washdown wastewater | 0 to 76 | <0.5 |

Scarfer emissions control wastewater is generated by a minority of facilities that operate wet scarfer emissions control. Only a portion of mills perform scarfing, and the majority of these mills either do not control scarfer emissions or operate dry emissions control. Exhaust gases from scarfers contain metal fumes comprising mainly iron oxides and the alloying elements of the steel. Because gases are saturated when exiting the scarfer hood, one of three wet emissions control systems is generally used: wet precipitator (intermittent spray wash), wet precipitator (continuous wash), and high energy venturi scrubber. Only two facilities specifically reported generating scarfer WAPC wastewater; both discharge flow rates were <10 gpt.

Finally, additional hot forming operations performed by some mills that generate contact cooling wastewater include hydraulic edging, hot shearing, die cooling, scarfer cooling, and saw cooling. EPA believes that these wastewaters are discharged with contact cooling wastewater because the survey respondents did not provide flow rate data for these sources.

7.1.5 Non-Integrated Steelmaking and Hot Forming Operations

The proposed non-integrated steelmaking and hot forming subcategory included two segments, carbon and alloy steel and stainless steel, because of differences in pollutants present in the wastewaters. EPA did not find discernable differences in water use practices, wastewater sources, and wastewater discharge flow rates between the segments; therefore, this discussion does not distinguish between the two segments. However, separate discussions are provided below for the following manufacturing processes within the subcategory: electric arc furnace (EAF) steelmaking, ladle metallurgy, vacuum degassing, continuous casting, and hot forming.

Approximately 67 percent of sites operate recycle systems specific to one type of operation. The remaining 33 percent of sites operate treatment and/or recycle systems for combined wastewater site operations, including vacuum degassing, continuous casting, and hot forming. The common characteristics of the process wastewater from each of these operations allows the sites to commingle and treat their wastewater simultaneously.

Electric Arc Furnace (EAF) Steelmaking

The Agency evaluated data from 69 survey respondents that reported that they performed non-integrated steelmaking operations. The analysis included a total of 76 EAF shops

and 132 EAFs. All EAFs in the United States are equipped with dry or semi-wet air pollution controls, and none discharge process wastewater. (One EAF shop has a wet scrubber system that functions as a backup.) Dry systems clean furnace off-gases without adding water to the gas cleaning system. Semi-wet systems apply water to the furnace off-gases to partially cool and condition the off-gases prior to particulate removal in an electrostatic precipitator. Sites achieve zero wastewater discharge from semi-wet systems by balancing the applied water with water that evaporates in the conditioning process. Non-contact cooling water is the predominant water source; however, some facilities use treated process water and plant service water. Wastewater is not recirculated.

Ladle Metallurgy

None of the 83 sites that perform ladle metallurgy and/or secondary steelmaking reported generating or discharging process wastewater from these operations. Water is used and discharged by vacuum degassers that often operate as part of ladle metallurgy stations. Water use and wastewater discharge by vacuum degassing is discussed below.

Vacuum Degassing

The vacuum generating system is the primary use of water and primary source of wastewater in vacuum degassing systems. Steam ejectors create a vacuum in the vacuum degassing systems; condensate wastewater is generated from this process. Molten steel exhaust comes in contact with the injected steam, thereby contaminating the condensate wastewater. Wastewater is recirculated at a high rate, and blowdown is the vacuum degassing wastewater stream. Sources of makeup water for the recirculation system include non-contact cooling water, plant service water, and treated or untreated process wastewater. Reported wastewater discharge flow rates ranged from 0 gpt to 116 gpt, with a median discharge flow rate of 19 gpt. The only other reported wastewater sources were boiler blowdown, cooling water leaks/spills, and mold cleaning water; each of these sources were reported by a single facility.

Continuous Casting

The primary use of water and primary source of wastewater in continuous casting are direct contact spray cooling (secondary cooling) of the partially solidified product as it exits the mold to produce a solid product. (Primary cooling and equipment cooling are non-contact cooling systems, which are not discussed in this section.) As the cast product surface oxidizes, scale is washed away by the cooling water. The spray water also becomes contaminated with oils and greases that are released by hydraulic and lubrication systems. Wastewater is recirculated at a high rate, and blowdown is the continuous casting wastewater stream. Sources of makeup water for the recirculation system include non-contact cooling water, plant service water, ground water, and treated or untreated process wastewater. Reported continuous caster wastewater discharge flow rates ranged from 0 gpt to 603 gpt, with a median discharge flow rate of 18 gpt.

Four sites reported generating equipment cleaning and washdown wastewater. Wastewater discharge rates for this source were <0.5 gpt. No additional process wastewater

sources were reported. Non-process wastewater sources often treated with process wastewater include losses from closed caster mold and machine cooling water systems.

Hot Forming

EPA identified contact water systems used for scale removal, roll and machinery cooling, product cooling, flume flushing, and other miscellaneous uses during the hot forming process as the primary use of water and primary wastewater source. EPA uses contact water systems as a generic term because there are many different sources of contact water within a hot forming mill. Sites may have multiple hot forming contact water systems. Section 7.1.4 describes water use and wastewater sources for hot forming operations in detail. Reported contact wastewater discharge flow rates ranged from 0 gpt to 11,644 gpt, with a median discharge flow rate of 39 gpt. Discharge flow rates for other common wastewater sources, including basement sumps, roll shop, equipment cleaning and washdown, and scarfer cooling and emissions control cannot be disclosed because it would compromise confidential business information.

Additional reported wastewater sources were site-specific, often generated by only one facility. Examples include lubricating, hot saw, and rail head hardening. Reported flow rates are not disclosed to prevent compromising confidential business information.

Non-process wastewater from hot forming operations that is treated with process wastewater includes non-contact cooling water from reheat furnaces, which is sometimes included in the process water recycle loop or recycled separately with a blowdown to the process water loop.

7.1.6 Steel Finishing Operations

The steel finishing subcategory, as proposed by EPA, included two segments, carbon and alloy steel and stainless steel, because of differences in pollutants present in the wastewaters. EPA also identified several manufacturing process divisions between the proposed segments. Separate discussions are provided below for the following manufacturing processes: acid pickling, cold forming, alkaline cleaning, stand-alone continuous annealing, hot coating, and electroplating.

Acid Pickling

For this analysis, EPA defines acid pickling as also including alkaline cleaning and salt bath and electrolytic sodium sulfate (ESS) descaling operations when performed on a line that includes acid pickling. In a small number of instances, continuous annealing operations with an associated water quench take place on acid pickling lines. In these instances, EPA considered discharge from the annealing rinse as a wastewater from acid pickling lines.

EPA identified three major uses of water and sources of wastewater from acid pickling lines: rinse water, pickle liquor, and WAPC devices. Rinse water comprises the largest

volume of wastewater from acid pickling lines to wastewater treatment. Multiple rinse tanks operated in series are used to clean the acid solution that carries over from acid pickling operations. Some sites operate countercurrent cascade rinsing whereby rinse water flows from one tank to another in the direction opposite of the product flow. Fresh water is added to the rinse tank located farthest from the pickling tanks. Although countercurrent cascade rinsing can reduce water use significantly, some sites operate once-through rinsing systems to maintain product quality.

Pickling is often performed in multiple tanks operated in series whereby acid solution cascades from the last tank to the first. Fresh acid and makeup water are added to the first pickling tank, and spent pickle liquor from the final pickling tank is blowdown. Spent pickle liquor is composed primarily of acid that is no longer an effective pickling agent. Spent pickle liquor may be regenerated on site, contract hauled off site, or discharged to wastewater treatment.

WAPC devices are located on acid pickling lines and at acid regeneration plants. Approximately 50 percent of WAPC systems recirculate wastewater, while 50 percent use once-through wastewater.

The range of and median wastewater discharge flow rates for selected wastewaters generated by acid pickling operations of strip and sheet (the predominant products) are listed below.

| Wastewater Source | Range of Discharge Flow Rates (gpt) | Median Discharge Flow Rate (gpt) |
|---|-------------------------------------|----------------------------------|
| Carbon and Alloy Strip/Sheet - Hydrochloric Acid | | |
| Pickling rinse wastewater | 0 to 1,374 | 63 |
| Pickling solution wastewater | 0 to 870 | 6 |
| WAPC | 0 to 809 | 14 |
| Carbon and Alloy Strip/Sheet - Sulfuric Acid | | |
| Pickling rinse wastewater | 0 to 310 | 7 |
| Pickling solution wastewater | 0 to 24 | 8 |
| WAPC wastewater | 6 to 343 | 108 |
| Stainless Strip/Sheet | | |
| Pickling rinse wastewater | 0 to 8,172 | 258 |
| Pickling solution wastewater | 0 to 1,704 | 3 |
| WAPC wastewater | 0 to 11,507 | 97 |

Other minor sources of wastewater reported by sites include process wastewater from other operations on the acid pickling lines (e.g., spent process baths and rinses from salt bath descaling); raw material handling, preparation, and storage; tank clean-outs; wet looping pits; equipment cleaning water; sumps; and pump seals. Except for blowdown from surface cleaning tanks, these wastewater sources are noncontinuous with minimal contribution to the total wastewater flow.

The Agency identified six sites that have acid pickling wastewaters contract hauled; these sites do not discharge acid pickling wastewater.

Cold Forming

The primary use of water in cold forming operations is in the contact spray water and rolling solution systems, and the primary cold forming wastewater is the blowdown from these systems. For purposes of analyzing wastewater flow rates, the Agency made no distinction between contact spray water systems and rolling solution systems, which can include blowdown from roll and/or roll table spray cooling and product cooling. Other reported sources of wastewater include equipment cleaning water, wastewater from roll shops, and basement sumps. The range of and median wastewater discharge flow rates for wastewaters generated by cold forming operations are listed below.

| Wastewater Source | Range of Discharge Flow Rates (gpt) | Median Discharge Flow Rate (gpt) |
|-------------------------------------|---|---|
| Carbon and Alloy | | |
| Multiple stand, combination | 3 to 319 | 115 |
| Multiple stand, direct application | 0 to 5,856 | 199 |
| Carbon and Alloy (continued) | | |
| Multiple stand, recirculation | 0 to 1,237 | 14 |
| Single stand, direct application | 0 to 360 | 2 |
| Single stand, recirculation | 0 to 76 | 7 |
| Stainless | | |
| Multiple stand, recirculation | 0 to 30 | 11 |
| Single stand, direct application | Not disclosed to prevent compromising confidential business information | Not disclosed to prevent compromising confidential business information |
| Single stand, recirculation | 0 to 82 | 5 |

Some carbon and alloy cold forming operations achieve zero discharge from their recycle system(s) through either contract hauling or discharge to other processes, such as acid pickling, casting, hot forming, vacuum degassing, and other cold forming operations.

Alkaline Cleaning

For this analysis, EPA defines alkaline cleaning operations as also including annealing operations performed on the same line. As a result, this segment includes both stand-alone alkaline cleaning lines and continuous annealing/alkaline cleaning lines.

The primary uses of water and primary sources of wastewater identified for alkaline cleaning operations are blowdown from the alkaline cleaning solution tanks and rinse water used to clean the alkaline cleaning solution from the steel. The range of and median wastewater discharge flow rates for solution blowdown and rinse wastewaters generated by alkaline cleaning of strip and sheet (the predominant products) are listed below.

| Wastewater Source | Range of Discharge Flow Rates (gpt) | Median Discharge Flow Rate (gpt) |
|--|--|---|
| Carbon and Alloy Steel, Strip/Sheet | | |
| Cleaning solution blowdown | 0 to 1,118 | 3 |
| Cleaning rinse wastewater | 0 to 2,271 | 162 |
| Stainless Steel, Strip/Sheet | | |
| Cleaning solution blowdown | 0.3 to 3,566 | 18 |
| Cleaning rinse wastewater | 39 to 15,082 | 2,257 |

Other reported minor sources of wastewater include: rinse water from annealing operations (when operated with a water quench), brush scrubbing, tank clean-outs, roll shop, and equipment cleaning and washdown water.

Continuous Annealing

For this analysis, EPA defines continuous annealing operations as those continuous annealing operations not on the same process line with other operations such as alkaline cleaning or acid pickling (i.e., stand-alone continuous annealing operations). Stand-alone continuous annealing operations are divided into two categories: lines that do not use water to quench the steel after the annealing process, and lines that do. Continuous annealing lines that operate without a water quench do not generate process wastewater. Sites with continuous annealing lines that operate with a water quench reported discharge flow rates ranging from <1 gpt to 672 gpt, with a median discharge flow rate of 21 gpt. A few quenching sites also reported generating small volumes of solution blowdown (<1 gpt).

Hot Coating

For this analysis, EPA defines hot coating as also including acid cleaning, annealing, alkaline cleaning, and other surface cleaning and preparation operations performed on the same line as a hot coating operation. Hot coating operations are performed on carbon and alloy steels only. The primary use of water and primary source of wastewater from hot coating operations are surface preparation operations, such as acid and alkaline cleaning, that the steel undergoes before hot coating. Twenty-four sites operate a total of 40 hot coating lines. Four of these operations reported a discharge from their hot coating tanks, but did not provide any flow data. Thirty-nine of the operations have a rinse following the coating operation. Rinse wastewater discharge flow rates ranged from 0 gpt to 4,044 gpt, with a median discharge flow rate of 182 gpt. Tank clean-outs, fume scrubbers, and equipment cleaning are other sources of wastewater reported by several sites.

Two of the lines reported operating without a discharge via contract hauling of process wastewater.

Electroplating

For this analysis, EPA defines electroplating lines as also including annealing, alkaline cleaning, acid cleaning, and other surface cleaning and surface preparation operations on the same line. Twenty-two sites reported performing electroplating on a total of 42 lines.

The primary uses of water and primary sources of wastewater from electroplating operations are acid and alkaline cleaning operations performed on the same process line, which generate solution blowdown and rinse wastewater. Wastewater discharge flow rates for electroplating operations vary by the type of metal applied and the product type. Some sites operate countercurrent cascade rinsing and other flow reduction techniques to conserve water; however, other sites require once-through rinsing to ensure product quality. At these sites, thorough rinsing after acid cleaning is critical for proper adhesion of the plating. The range and median wastewater discharge flow rates by metal type for these wastewater streams are listed below. Wastewater discharge flow rates for plate electroplating are not disclosed to prevent compromising confidential business information.

| Wastewater Source | Range of Discharge Flow Rates (gpt) | Median Discharge Flow Rate (gpt) |
|------------------------------------|-------------------------------------|----------------------------------|
| Chrome/Tin Electroplating | | |
| Cleaning solution blowdown | 0 to 8,938 | 1.5 |
| Cleaning rinse wastewater | 0 to 54,444 | 154 |
| Other Metals Electroplating | | |
| Cleaning solution blowdown | 0 to 74,691 | 5.3 |
| Cleaning rinse wastewater | 0 to 1,554 | 26 |

Other minor wastewater sources reported by several sites include electroplating solution blowdown and rinse water, plating solution losses, fume scrubbers, tank clean-outs, equipment cleaning, and spills/leaks.

7.1.7 Other Operations

The Other Operations Subcategory includes segments for direct-reduced ironmaking, forging, and briquetting.

Direct-Reduced Ironmaking (DRI)

Three DRI plants provided industry survey data. One plant was operated at a non-integrated site and two were operated as stand-alone DRI sites. WAPC systems, used to control furnace emissions and emissions from material handling and storage, are the primary reported use of water and primary source of wastewater for DRI operations. All three sites recirculate WAPC wastewater. WAPC wastewater discharge flow rates ranged from 0 gpt to 64 gpt, with a median discharge flow rate of 2.2 gpt.

Forging

Contact water is the primary use of water and primary source of process wastewater from forging operations. Contact water is used for flume flushing, descaling, die spray cooling, and product quenching. Forging wastewater sources and generation are very similar to those for hot forming; Section 7.1.5 describes water use and wastewater sources for hot forming operations in detail. Reported forging contact wastewater discharge flow rates ranged from 0 gpt to 1,110 gpt, with a median wastewater discharge flow rate of 117 gpt.

Other minor wastewater sources reported include hydraulic system wastewater, equipment cleaning water, and basements sumps.

Briquetting

The Agency found that briquetting operations do not generate or discharge process wastewater.

7.2 Identification of Pollutants of Concern (POCs)

This section presents the approach used for identifying POCs and lists the POCs that EPA considered for this rulemaking. EPA presents this information using the subcategories as proposed. Memoranda describing the POC identification in more detail and the data used to identify the POCs are located in the Iron and Steel Administrative Record (Section 5.4, DCN IS05030 and Section 14.3, DCN IS10616). EPA used the POCs for each subcategory to screen pollutants for possible regulation; Section 12 describes the selection of regulated pollutants for each subcategory from the list of POCs. EPA also used the POCs to calculate pollutant loadings and removals and to perform an environmental assessment for each subcategory.

To identify POCs, EPA used analytical data for over 300 analytes collected during sampling episodes conducted by EPA at 18 iron and steel facilities; in addition, EPA used analytical data from 2 dioxins/furans sampling episodes to confirm the presence of dioxins/furans in sintering wastewater. Section 3 provides more details on EPA's sampling program, the analytical methods used, and the individual analytes analyzed for during the sampling episodes. In general, EPA analyzed wastewater samples for conventional pollutants (pH, total suspended solids, and biochemical oxygen demand), bulk nonconventional pollutants, volatile and semivolatile organic pollutants, metals, and dioxins and furans. The list of pollutants analyzed for each subcategory depended on the types of pollutants EPA expected to find in wastewater discharged from operations in the subcategory; pollutants not analyzed for a particular subcategory are noted in the subcategory-specific subsections below.

EPA used the following general criteria for selecting POCs for each subcategory:

- EPA considered three pollutants as POCs for all manufacturing processes: total suspended solids (TSS), oil and grease measured as hexane extractable material (HEM), and total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM). These pollutants are important wastewater characteristics and are important indicators of wastewater treatment system performance in many applications in the steel industry.
- EPA did not evaluate pH as a candidate POC since pH is not expressed in terms of quantity or concentration. However, the pH level is an important wastewater characteristic and an important indicator of wastewater treatment system performance in many applications in the steel industry.
- Except where specifically noted, EPA excluded the following pollutants from consideration as POCs for all manufacturing processes because they are either dissolved substances or common elements found in wastewater: total dissolved solids (TDS), calcium, chloride, sodium, total sulfide, and sulfate.

In addition to the general criteria listed above, EPA used the following methodology to identify POCs. First, EPA eliminated from consideration all pollutants not detected in untreated wastewater samples from specific manufacturing processes during EPA's 18 sampling episodes. Table 7-2 presents the list of 147 pollutants that were not detected in any manufacturing-process-specific untreated wastewater samples. For the remaining pollutants, EPA reviewed its data from untreated wastewater samples from individual manufacturing processes to identify pollutants present in wastewaters from each process. EPA identified POCs for each manufacturing process using the following criteria:

- The pollutant was detected at greater than or equal to 10 times the minimum level (ML, also referred to as baseline value (see Section 4)) concentration in at least 10 percent of all untreated process wastewater

samples. This criterion ensures that the pollutant was present at treatable concentrations at sites where EPA evaluated treatment performance.

- The mean detected concentration in untreated process wastewater samples was greater than the mean detected concentration in source water samples. This criterion ensures that pollutants are generated by the manufacturing process rather than merely reflecting background pollutant concentrations.

Using the criteria above, EPA developed segment- and/or operation-level POC lists for each of the seven subcategories. The following subsections present tables that list the POCs for each subcategory/segment. The following subsections also present tables for each subcategory listing the pollutants that were detected in at least one untreated process wastewater sample, but failed the POC for the subcategory. These additional tables, together with Table 7-2 and the POC tables document the status of all the pollutants analyzed in untreated process wastewater samples for each subcategory.

Note that while EPA evaluated POCs based on an assessment of untreated process wastewater data at the subcategory, segment, or operational level, certain tables provided in this section represent assessments at the subcategory level only in order to be concise. As a result, certain information presented in the subcategory-level tables may appear contradictory. For example, for the steel finishing subcategory, mercury is shown in Table 7-16 as both not detected and as detected, but not greater than 10 times the minimum level in at least 10 percent of samples. In this case, mercury was not detected in any untreated wastewater samples for certain steel finishing operations, but was detected at low levels in other steel finishing operations. See the memoranda describing the POC identification located in the Iron and Steel Administrative Record (Section 5.4, DCN IS05030 and Section 14.3, DCN IS10616) for detailed information presented by subcategory/segment/operation.

7.2.1 Cokemaking Subcategory

The cokemaking subcategory is divided into two segments: by-product recovery and non-recovery. EPA did not identify POCs for the non-recovery segment because non-recovery cokemaking operations do not generate process wastewater. The identification of POCs for the by-product segment is discussed below.

EPA reviewed untreated wastewater data from four by-product cokemaking facilities (a total of 4 sampling points and 16 samples) to identify POCs for the by-product segment of the cokemaking subcategory. EPA did not analyze by-product cokemaking wastewater samples for hexavalent chromium because EPA did not expect this pollutant to be present at treatable concentrations in cokemaking wastewaters. Table 7-3 presents pollutants that were detected in iron and steel untreated process wastewater, but not identified as POCs for this subcategory.

Table 7-4 lists the POCs identified for this segment. EPA identified 68 POCs using the criteria presented in Section 7.2; in addition, EPA selected total Kjeldahl nitrogen (TKN), weak acid dissociable (WAD) cyanide, thiocyanate, and nitrate/nitrite as POCs.

TKN, WAD cyanide, and thiocyanate could not be evaluated using the criteria presented in Section 7.2 because no minimum levels are specified for these analyses. EPA selected these three pollutants as POCs because they are widely present in cokemaking wastewater (each was detected in 100 percent of EPA's cokemaking untreated wastewater samples). Nitrate/nitrite failed the screening criteria in Section 7.2 because the mean detected concentration of nitrate/nitrite was greater in source water samples than in untreated wastewater samples. However, EPA selected nitrate/nitrite as a POC because it is an important indicator of biological treatment effectiveness.

7.2.2 Ironmaking Subcategory

The proposed ironmaking subcategory was divided into the following two segments: sintering and blast furnace ironmaking. Because the characteristics of sintering and blast furnace ironmaking wastewater are different, EPA identified different POCs for the two proposed segments. The POCs for each segment are discussed below. EPA did not analyze sintering and blast furnace ironmaking wastewater samples for biochemical oxygen demand and hexavalent chromium because EPA did not expect these pollutants to be present at treatable concentrations in ironmaking wastewaters. Table 7-5 presents pollutants that were detected in iron and steel untreated process wastewater, but not identified as POCs for this subcategory.

Sintering

EPA reviewed untreated wastewater data from two sintering facilities (a total of 2 sampling points and 10 samples) to identify POCs for sintering. Table 7-6 lists the POCs identified for this segment. EPA identified 62 POCs using the criteria presented in Section 7.2. In addition, EPA selected TKN, WAD cyanide, and thiocyanate as POCs.

TKN, WAD cyanide, and thiocyanate could not be evaluated using the criteria presented in Section 7.2 because no minimum levels are specified for these analyses. EPA selected these three pollutants as POCs because they are widely present in sintering wastewater (each was detected in 100 percent of EPA's sintering untreated wastewater samples).

Dioxins and furans were detected during the two sampling episodes conducted by EPA. To confirm that dioxins and furans are present in sintering wastewaters, EPA collected additional sampling data in collaboration with the American Iron and Steel Institute. These data, while not included in this POC analysis, further characterized the presence and amount of dioxins and furans in sintering wastewater and confirmed EPA's data.

Blast Furnace Ironmaking

EPA reviewed untreated wastewater data from three blast furnace ironmaking facilities (a total of 4 sampling points and 20 samples) to identify POCs for blast furnace ironmaking. Table 7-7 lists the POCs identified for this segment. EPA identified 24 POCs using the criteria presented in Section 7.2; in addition, EPA selected TKN, WAD cyanide, and thiocyanate as POCs.

TKN, WAD cyanide, and thiocyanate could not be evaluated using the criteria presented in Section 7.2 because no minimum levels are specified for these analyses. EPA selected these three pollutants as POCs because they are widely present in blast furnace wastewater (each was detected in at least 60 percent of EPA's blast furnace ironmaking untreated wastewater samples).

7.2.3 Integrated Steelmaking Subcategory

The proposed integrated steelmaking subcategory included the following manufacturing processes that generate process wastewater: basic oxygen furnace (BOF) steelmaking, vacuum degassing, and continuous casting. Because wastewaters from these three manufacturing processes are commonly cotreated, the list of POCs for this subcategory includes all pollutants identified as POCs for any of the three manufacturing processes. EPA did not analyze steelmaking wastewater samples for biochemical oxygen demand, total organic carbon, total sulfide, cyanide, thiocyanate, and hexavalent chromium because EPA did not expect these pollutants to be present at treatable concentrations in steelmaking wastewaters. Table 7-8 presents pollutants that were detected in iron and steel untreated process wastewater, but not identified as POCs for this subcategory.

EPA identified a total of 28 POCs for this subcategory. The POCs for each specific manufacturing process are discussed below; Table 7-9 lists the POCs identified for the proposed integrated steelmaking subcategory and for each manufacturing process.

EPA reviewed untreated steelmaking wastewater data from three BOF steelmaking facilities (a total of 7 sampling points and 28 samples) to identify POCs for BOF steelmaking operations. EPA identified 28 POCs using the criteria presented in Section 7.2.

EPA reviewed untreated vacuum degassing wastewater data from two BOF steelmaking facilities performing vacuum degassing (a total of two sampling points and six samples) to identify POCs for vacuum degassing operations. EPA identified 15 POCs using the criteria presented in Section 7.2.

EPA reviewed untreated continuous casting wastewater data from three BOF steelmaking facilities performing continuous casting (a total of 3 sampling points and 14 samples) to identify POCs for continuous casting operations. EPA identified 12 POCs using the criteria presented in Section 7.2; in addition, EPA selected lead as a POC. Lead failed the screening criteria in Section 7.2 because the mean detected concentration of lead was not greater

than 10 times the minimum level. However, EPA selected lead as a POC because industry-supplied effluent data indicate that lead was detected in 129 of the 262 samples (49 percent) from integrated continuous casting operations. In addition, EPA selected lead as a POC for continuous casting operations because it is regulated under the 1982 regulation (Reference 7-1) and data collected in support of the 1982 regulation indicate it is present in wastewater discharged from continuous casting operations.

7.2.4 Integrated and Stand-Alone Hot Forming Subcategory

The proposed integrated and stand-alone hot forming subcategory was divided into two segments: carbon and alloy steel and stainless steel. Because the characteristics of hot forming wastewater are affected by steel type, EPA identified different POCs for the two segments. The POCs for each segment are discussed below. EPA did not analyze integrated and stand-alone hot forming wastewater samples for dioxins and furans, cyanide, thiocyanate, biochemical oxygen demand, total sulfide, and hexavalent chromium because EPA did not expect these pollutants to be present at treatable concentrations in hot forming wastewaters. Table 7-10 presents pollutants that were detected in iron and steel untreated process wastewater, but not identified as POCs for this subcategory.

Integrated and Stand-Alone Hot Forming - Carbon and Alloy Steel

EPA reviewed untreated wastewater data from two carbon and alloy steel integrated hot forming facilities (a total of 4 sampling points and 15 samples) to identify POCs for hot forming operations. Table 7-11 lists the POCs identified for this segment. EPA identified 10 POCs using the criteria presented in Section 7.2; in addition, EPA selected lead as a POC. Lead failed the screening criteria in Section 7.2 because the mean detected concentration of lead was not greater than 10 times the minimum level. However, EPA selected lead as a POC because industry-supplied effluent data indicate that lead was detected in 38 of the 168 samples (23 percent) from integrated and stand-alone hot forming operations.

Integrated and Stand-Alone Hot Forming - Stainless Steel

EPA did not sample any stainless steel integrated or stand-alone hot forming facilities. EPA did sample stainless steel non-integrated hot forming operations. Since the hot forming processes performed and type of steel formed are identical for the stainless steel segments, EPA transferred the 15 POCs from the non-integrated steelmaking and hot forming subcategory to the integrated and stand-alone hot forming subcategory, stainless steel segment. (see Section 7.2.5 for a discussion of the selection of these POCs). Table 7-12 lists the POCs for this segment.

7.2.5 Non-Integrated Steelmaking and Hot Forming Subcategory

The proposed non-integrated steelmaking and hot forming subcategory was divided into two segments: carbon and alloy steel and stainless steel. Because the characteristics of the steelmaking and hot forming wastewater generated are affected by steel type, EPA

identified different POCs for the two segments. The POCs for each segment are discussed in the following subsections. EPA did not analyze non-integrated steelmaking and hot forming wastewater samples for dioxins and furans, cyanide, thiocyanate, biochemical oxygen demand, and total sulfide because EPA did not expect these pollutants to be present at treatable concentrations in non-integrated steelmaking and hot forming wastewaters. Table 7-13 presents pollutants that were detected in iron and steel untreated wastewater, but not identified as POCs for this subcategory.

Non-Integrated Steelmaking and Hot Forming - Carbon and Alloy Steel

The non-integrated steelmaking and hot forming subcategory, carbon and alloy steel segment included the following manufacturing processes that generate wastewater: vacuum degassing, continuous casting, and hot forming. Because wastewaters from these manufacturing processes are commonly cotreated, the list of POCs for the entire segment includes all pollutants identified as POCs for any of the manufacturing processes. EPA identified a total of 15 POCs for this segment. The POCs for each specific manufacturing process are discussed below; Table 7-14 lists the POCs identified for this segment, and for each manufacturing process.

EPA did not identify POCs for vacuum degassing because EPA did not sample non-integrated vacuum degassing operations during its sampling program. Based on process chemistry and the steel material processed, EPA determined that it is unlikely that wastewater associated with this operation would contain pollutants not identified as POCs in the other manufacturing processes in this segment. POCs identified for continuous casting and hot forming apply to vacuum degassing.

EPA reviewed untreated continuous casting wastewater data from three non-integrated steelmaking facilities performing continuous casting on carbon and alloy steel (a total of three sampling points and three samples) to identify POCs for continuous casting operations. EPA identified 12 POCs using the criteria presented in Section 7.2; in addition, EPA selected lead and zinc as POCs. Lead failed the screening criteria in Section 7.2 because the mean detected concentration of lead was not greater than 10 times the minimum level. Zinc failed because the mean detected concentration of zinc was greater in source water samples than in untreated wastewater samples. However, EPA selected lead and zinc as POCs because industry-supplied effluent data indicate that lead was detected in 65 of the 72 samples (90 percent) and zinc was detected in 70 of the 72 (97 percent) from non-integrated continuous casting operations on carbon and alloy steel. In addition, EPA selected lead and zinc as POCs for continuous casting operations because both pollutants are regulated under the 1982 regulation (Reference 7-1) and data collected in support of the 1982 regulation indicate that these pollutants were present in wastewater discharged from continuous casting operations (no distinction was made between steel type in the 1982 regulation).

EPA reviewed untreated hot forming wastewater data from three non-integrated steelmaking facilities conducting hot forming on carbon and alloy steel (a total of three sampling points and three samples) to identify POCs for hot forming operations. EPA identified 11 POCs using the criteria presented in Section 7.2; in addition, EPA selected lead and zinc as POCs.

Lead failed the screening criteria in Section 7.2 because it was not detected in EPA's sampling program. Zinc failed because the mean detected concentration of zinc was not greater than 10 times the minimum level. EPA selected lead and zinc as POCs because industry-supplied effluent data indicate that lead was detected in 229 of the 237 samples (97 percent) and zinc was detected in 200 of the 237 (84 percent) from non-integrated hot forming operations on carbon and alloy steel.

Non-Integrated Steelmaking and Hot Forming - Stainless Steel

The proposed non-integrated steelmaking and hot forming subcategory, stainless steel segment included the following manufacturing processes that generate wastewater: vacuum degassing, continuous casting, and hot forming. Because wastewaters from these manufacturing processes are commonly cotreated, the list of POCs for the entire segment includes all pollutants identified as POCs for any of the manufacturing processes. EPA identified a total of 22 POCs for this segment. The POCs for each specific manufacturing process are discussed below; Table 7-15 lists the POCs identified for this segment and for each manufacturing process.

EPA did not identify POCs for vacuum degassing because EPA did not sample non-integrated vacuum degassing operations during its sampling program. Based on process chemistry, EPA determined that it is unlikely that wastewater associated with this operation would contain pollutants not identified as POCs in the other manufacturing processes this segment. POCs identified for continuous casting and hot forming apply to vacuum degassing.

EPA reviewed untreated continuous casting wastewater data from two non-integrated steelmaking facilities performing continuous casting of stainless steel (a total of two sampling points and seven samples) to identify POCs for continuous casting operations. EPA identified 19 POCs using the criteria presented in Section 7.2; in addition, EPA selected lead and zinc as POCs. Lead failed the screening criteria in Section 7.2 because it was not detected in EPA's sampling program. Zinc failed because the mean detected concentration of zinc was not greater than 10 times the minimum level. EPA selected lead and zinc as POCs because industry-supplied effluent data indicate that lead was detected in 12 of the 13 samples (92 percent) and zinc was detected in 13 of the 13 samples (100 percent) from non-integrated continuous casting operations on stainless steel. In addition, EPA selected lead and zinc as POCs for continuous casting operations because both pollutants are regulated under the 1982 regulation (Reference 7-1) and data collected in support of the 1982 regulation indicate that these pollutants were present in wastewater discharged from continuous casting operations (no distinction was made between steel type in the 1982 regulation).

EPA reviewed untreated hot forming wastewater data from two non-integrated steelmaking facilities performing hot forming of stainless steel (a total of two sampling points and seven samples) to identify POCs for hot forming operations. EPA identified 15 POCs for hot forming using the criteria presented in Section 7.2.

7.2.6 Steel Finishing Subcategory

The proposed steel finishing subcategory was divided into two segments: carbon and alloy steel and stainless steel. Because the characteristics of the steel finishing wastewater generated are affected by steel type, EPA identified different POCs for the two segments. The POCs for each segment are discussed below. EPA did not analyze steel finishing wastewater samples for dioxins and furans, cyanide, thiocyanate, biochemical oxygen demand, and total sulfide because EPA did not expect these pollutants to be present at treatable concentrations in steel finishing wastewaters. Table 7-16 presents pollutants that were detected in iron and steel untreated wastewater, but not identified as POCs for this subcategory.

Steel Finishing - Carbon and Alloy Steel

The proposed steel finishing subcategory, carbon and alloy steel segment included the following manufacturing processes that generate wastewater: acid pickling, cold forming, alkaline cleaning, stand-alone continuous annealing, hot coating, and electroplating. Because wastewaters from these manufacturing processes are commonly cotreated, the list of POCs for the entire segment includes all pollutants identified as POCs for any of the manufacturing processes. EPA identified a total of 37 POCs for this segment. The POCs for each specific manufacturing process are discussed below; Table 7-17 lists the POCs identified for this segment and for each manufacturing operation.

EPA reviewed untreated wastewater data from four facilities performing acid pickling on carbon and alloy steel (a total of 5 sampling points and 19 samples) to identify POCs for acid pickling operations. EPA identified 18 POCs using the criteria presented in Section 7.2; in addition, EPA selected sulfate as a POC. EPA selected sulfate as a POC because it is present in sulfuric acid pickling wastewater, which EPA did not sample.

EPA reviewed untreated wastewater data from two facilities performing cold forming on carbon and alloy steel (a total of 3 sampling points and 14 samples) to identify POCs for cold forming operations. EPA identified 25 POCs using the criteria presented in Section 7.2; in addition, EPA selected zinc as a POC. Zinc failed the screening criteria in Section 7.2 because the mean detected concentration of zinc in source water was greater than in untreated wastewater. However, EPA selected zinc as a POC because zinc is regulated under the 1982 regulation (Reference 7-1).

EPA reviewed untreated wastewater data from two facilities performing alkaline cleaning on carbon and alloy steel (a total of 4 sampling points and 12 samples) to identify POCs for alkaline cleaning operations. EPA identified 12 POCs for alkaline cleaning using the criteria presented in Section 7.2.

EPA did not identify POCs for stand-alone continuous annealing for carbon and alloy steel because EPA did not sample any annealing quenching operations during its sampling program. However, because quenching is simply a direct-contact water cooling process with no chemicals involved, EPA determined that wastewater associated with this operation is unlikely to

contain pollutants not identified as POCs in other finishing manufacturing process operations. POCs identified for the other finishing processes apply to continuous annealing.

EPA reviewed untreated wastewater data from two facilities performing hot coating on carbon and alloy steel (a total of two sampling points and six samples), including chromium-bearing rinsing operations, to identify POCs for hot coating operations. EPA identified 22 POCs for hot coating using the criteria presented in Section 7.2.

EPA reviewed untreated wastewater data from four facilities performing electroplating on carbon and alloy steel (a total of 6 sampling points and 24 samples) to identify POCs for electroplating operations. The types of electroplating operations sampled include zinc, zinc-nickel, tin (chromium-bearing), and chromium. EPA identified 19 POCs for electroplating using the criteria presented in Section 7.2.

Steel Finishing - Stainless Steel

The proposed steel finishing subcategory, stainless steel segment included the following manufacturing processes that generate wastewater: acid pickling and descaling, cold forming, alkaline cleaning, and stand-alone continuous annealing. Because wastewaters from these manufacturing processes are commonly cotreated, the list of POCs for the entire segment includes all pollutants identified as POCs for any of the manufacturing processes. EPA identified a total of 49 POCs for this segment. The POCs for each specific manufacturing process are discussed below; Table 7-18 lists the POCs identified for this segment and for each manufacturing operation.

EPA reviewed untreated wastewater data from two facilities performing acid pickling, electrolytic sodium sulfate (ESS) descaling, and salt bath descaling on stainless steel (a total of 5 sampling points and 22 samples) to identify POCs for acid pickling and descaling operations. EPA identified 30 POCs for acid pickling and descaling. EPA identified 29 POCs using the criteria presented in Section 7.2; in addition, EPA selected cyanide as a POC. EPA selected cyanide as a POC because it is present in reducing salt bath descaling wastewater (Reference 7-1), which EPA did not sample.

EPA reviewed untreated wastewater data from one facility performing cold forming on stainless steel (a total of 2 sampling points and 10 samples) to identify POCs for cold forming operations. EPA identified 40 POCs for cold forming using the criteria presented in Section 7.2.

EPA reviewed untreated wastewater data from one facility performing alkaline cleaning on stainless steel (a total of one sampling point and five samples) to identify POCs for alkaline cleaning operations. EPA identified 10 POCs for alkaline cleaning using the criteria presented in Section 7.2.

EPA did not identify POCs for stand-alone continuous annealing for stainless steel because EPA did not sample any annealing quenching operations during its sampling

program. However, because quenching is simply a direct-contact water cooling process with no chemicals involved, EPA determined that wastewater associated with this operation is unlikely to contain pollutants not identified as POCs in other finishing manufacturing process operations. POCs identified for the other finishing processes apply to continuous annealing.

7.2.7 Other Operations Subcategory

The other operations subcategory is divided into three segments: direct-reduced ironmaking (DRI), forging, and briquetting. The POCs for each segment are discussed below.

EPA reviewed untreated wastewater data from one facility performing DRI operations (a total of one sample) to identify POCs for DRI operations. EPA did not analyze DRI wastewater samples for dioxins and furans, cyanide, thiocyanate, biochemical oxygen demand, and total sulfide because EPA did not expect these pollutants to be present at treatable concentrations in DRI wastewaters. Table 7-19 presents pollutants that were detected in iron and steel untreated wastewater, but not identified as POCs for this subcategory. EPA identified 10 POCs for the DRI segment using the criteria presented in Section 7.2. Table 7-20 lists the POCs identified for the DRI segment.

Based on an analysis of industry-supplied data, EPA determined that the principal pollutants from forging are TSS and oil and grease. EPA did not identify any specific priority and nonconventional POCs for forging because EPA lacked data for these pollutants.

Briquetting operations do not discharge process wastewater; therefore, EPA did not identify POCs for the briquetting segment.

7.3 Untreated Process Wastewater Characterization Data for Pollutants of Concern

Tables 7-21 through 7-27 present untreated process wastewater characterization data for POCs for each subcategory in the iron and steel industry, to the extent that it does not disclose confidential business information. Data presented in these tables include for each pollutant the number of times analyzed, number of times detected, percentage of samples detected greater than 10 times minimum level, mean concentration of detects, median concentration of detects, detection limit range, and the minimum level. Data from all sampling points representing a particular subcategory were combined to calculate the mean and median detected concentrations. The mean and the median concentrations were calculated for each pollutant using only data from samples where the pollutant was detected; data from samples where the pollutant was not detected were not used to calculate the mean and median concentrations.

As discussed in Section 7.2, POCs were identified based on an assessment performed at the subcategory, segment, or operation level, while the untreated process wastewater characterization data are presented in Tables 7-22 through 7-28 at the subcategory level. EPA chose to present untreated process wastewater characterization data at the

subcategory level to present as much information as possible without compromising confidential business information. As a result, certain information presented in these tables may not appear to meet the criteria for selecting POCs presented in Section 7.2. For example, Table 7-27 for the steel finishing subcategory shows that selenium is detected at concentrations greater than 10 times the minimum level in 3 percent of the samples (compared to 10 percent of samples as specified by the POC selection criteria). In this case, selenium met the POC criteria for a subset of the steel finishing operations shown in Tables 7-17 and 7-18.

7.4 References

- 7-1 U.S. Environmental Protection Agency. Development Document for Effluent Guidelines and Standards for the Iron and Steel Manufacturing Point Source Category. EPA 440/1-82/024, Washington, DC, May 1982.

Table 7-1

1997 National Estimate of Annual Discharge from Manufacturing Operations by Discharge Type

| Manufacturing Operation | Total Number of Sites (a) | Total Annual Discharge Rate (1,000 gallons per year) | Number (%) of Direct Dischargers | Annual Discharge Rate for Direct Dischargers (1,000 gallons per year) | Number (%) of Indirect Dischargers | Annual Discharge Rate for Indirect Dischargers (1,000 gallons per year) | Number (%) of Zero Dischargers (b) |
|--|---------------------------|--|----------------------------------|---|------------------------------------|---|------------------------------------|
| Cokemaking | 24 | 3,031,000 | 14 (58%) | 2,450,000 | 8 (33%) | 581,000 | 2 (8%) |
| Sintering | 9 | 2,110,000 | 4 (44%) | 2,110,000 | 0 (0%) (c) | 0 (c) | 5 (56%) |
| Blast furnace ironmaking | 20 | 7,914,000 | 13 (62%) | 7,630,000 | 1 (5%) | 284,000 | 7 (33%) |
| BOF steelmaking | 20 | 6,371,110 | 17 (81%) | 6,370,000 | 1 (5%) | 1,110 | 3 (14%) |
| EHF steelmaking | 96 | 0 (c) | 3 (3%) | 0 (c) | 2 (2%) | 0 (c) | 92 (96%) |
| Vacuum degassing | 44 | 1,270,000 | 26 (59%) | 1,250,000 | 4 (9%) | 20,000 | 14 (32%) |
| Ladle metallurgy | 103 | 0 (c) | 0 (0%) (c) | 0 (c) | 0 (0%) (c) | 0 (c) | 103 (100%) |
| Continuous Casting | 113 | 10,573,000 | 53 (47%) | 10,100,000 | 17 (15%) | 473,000 | 43 (38%) |
| Hot forming | 153 | 140,772,000 | 87 (57%) | 140,000,000 | 29 (19%) | 772,000 | 39 (25%) |
| Acid pickling and descaling | 69 | 13,755,000 | 50 (72%) | 13,400,000 | 14 (20%) | 355,000 | 7 (10%) |
| Cold forming | 103 | 9,479,600 | 39 (38%) | 9,420,000 | 16 (16%) | 59,600 | 52 (50%) |
| Surface cleaning and coating (d) | 98 | 14,519,000 | 53 (54%) | 13,800,000 | 33 (34%) | 719,000 | 14 (14%) |
| Briquetting or other agglomeration process | 4 | 0 (c) | 0 (0%) (c) | 0 (c) | 0 (0%) (c) | 0 (c) | 4 (100%) |
| Direct-reduced ironmaking | 2 | 119,000 | 1 (50%) | 78,600 | 1 (50%) | 40,500 | 0 (0%) |

Source: U.S. EPA, U.S. EPA Collection of 1997 Iron and Steel Industry Data (Detailed and Short Surveys).

- (a) The sum of direct, indirect, and zero dischargers may not equal the total number of operations. Sites may discharge wastewater both directly and indirectly from their manufacturing operations.
- (b) Zero dischargers include operations that do not discharge process wastewater (either by 100 percent recycle/reuse or by alternative discharge practices, such as contract hauling or evaporation) and operations that are completely dry.
- (c) Cells with a zero (0) indicate that none of the survey respondents have the characteristic; however, it is possible for nonsurveyed facilities to have the characteristic.
- (d) Surface cleaning and coating operations include: alkaline cleaning, stand-alone continuous annealing, hot coating, and electroplating.

Table 7-2**Pollutants Not Detected in Untreated Wastewater Samples (a)**

| Pollutant Name | |
|---|------------------------------|
| <i>Nonconventional Metals</i> | |
| Cadmium, Dissolved | Cobalt, Dissolved |
| Silver, Dissolved | Thallium, Dissolved |
| Tin, Dissolved | Vanadium, Dissolved |
| <i>Priority Organic Pollutants</i> | |
| Acrolein | Bis(2-chloroisopropyl) Ether |
| Bromodichloromethane | Bromomethane |
| 4-Bromophenyl Phenyl Ether | Butyl Benzyl Phthalate |
| Chlorobenzene | Chloroethane |
| 2-Chloroethylvinyl Ether | Chloromethane |
| 2-Chloronaphthalene | 2-Chlorophenol |
| 4-Chlorophenylphenyl Ether | Di-n-butyl Phthalate |
| 1,2-Dichlorobenzene | 1,3-Dichlorobenzene |
| 1,4-Dichlorobenzene | 3,3'-Dichlorobenzidine |
| 1,1-Dichloroethane | 1,1-Dichloroethene |
| trans-1,2-Dichloroethene | 2,4-Dichlorophenol |
| 1,2-Dichloropropane | Diethyl Phthalate |
| Dimethyl Phthalate | 2,4-Dinitrophenol |
| 2,4-Dinitrotoluene | 2,6-Dinitrotoluene |
| Di-n-octyl Phthalate | Di-n-propylnitrosamine |
| Hexachlorobenzene | Hexachlorobutadiene |
| Hexachlorocyclopentadiene | Hexachloroethane |
| Isophorone | 2-Methyl-4,6-dinitrophenol |
| N-Nitrosodimethylamine | Pentachlorophenol |
| 1,1,1,2-Tetrachloroethane | Tetrachloroethene |
| Tetrachloromethane | 1,2,4-Trichlorobenzene |

Table 7-2 (Continued)

| Pollutant Name | |
|--|-----------------------------|
| <i>Priority Organic Pollutants (continued)</i> | |
| 1,1,2-Trichloroethane | 2,4,6-Trichlorophenol |
| Vinyl Chloride | |
| <i>Nonconventional Organic Pollutants</i> | |
| o-Anisidine | Aramite |
| Benzanthrone | 1-Bromo-2-chlorobenzene |
| 1-Bromo-3-chlorobenzene | Chloroacetonitrile |
| p-Chloroaniline | 2-Chloro-1,3-butadiene |
| 4-Chloro-2-nitroaniline | 1-Chloro-3-nitrobenzene |
| 3-Chloropropene | 5-Chloro-o-toluidine |
| Crotonaldehyde | Crotoxypfos |
| p-Cymene | 2,4-Diaminotoluene |
| 1,2-Dibromo-3-chloropropane | 1,2-Dibromoethane |
| 3,5-Dibromo-4-hydroxy-benzonitrile | Dibromomethane |
| 2,3-Dichloroaniline | trans-1,4-Dichloro-2-butene |
| 2,6-Dichloro-4-nitroaniline | 2,3-Dichloronitrobenzene |
| 2,6-Dichlorophenol | 1,3-Dichloropropane |
| 1,3-Dichloro-2-propanol | cis-1,3-Dichloropropene |
| 1,2:3,4-Diepoxybutane | Diethyl Ether |
| 3,3'-Dimethoxybenzidine | p-Dimethylaminoazobenzene |
| 7,12-Dimethylbenz(a)anthracene | 1,4-Dinitrobenzene |
| Diphenyl Ether | Diphenyldisulfide |
| Ethyl Cyanide | Ethyl Methacrylate |
| Ethyl Methanesulfonate | Ethylenethiourea |
| Hexachloropropene | 2-Hexanone |
| Iodomethane | Isobutyl Alcohol |
| 2-Isopropyl-naphthalene | Isosafrole |
| Longifolene | Malachite Green |

Table 7-2 (Continued)

| Pollutant Name | |
|---|------------------------------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | |
| Mestranol | Methapyrilene |
| Methyl Isobutyl Ketone | Methyl Methacrylate |
| Methyl Methanesulfonate | 2-Methylbenzothiazole |
| 3-Methylcholanthrene | 4,4'-Methylenebis(2-chloroaniline) |
| 2-Methyl-2-propenenitrile | 2-(Methylthio)benzothiazole |
| 1,5-Naphthalenediamine | 1,4-Naphthoquinone |
| 2-Nitroaniline | 3-Nitroaniline |
| 4-Nitroaniline | 4-Nitrobiphenyl |
| N-Nitrosodi-n-butylamine | N-Nitrosodiethylamine |
| N-Nitrosomethylethylamine | N-Nitrosomethylphenylamine |
| N-Nitrosomorpholine | N-Nitrosopiperidine |
| 5-Nitro-o-toluidine | Pentachlorobenzene |
| Pentachloroethane | Pentamethylbenzene |
| Phenacetin | Phenothiazine |
| 1-Phenylnaphthalene | Pronamide |
| 2-Propen-1-ol | Safrole |
| Squalene | 1,2,4,5-Tetrachlorobenzene |
| 1,1,1,2-Tetrachloroethane | 2,3,4,6-Tetrachlorophenol |
| Thioacetamide | Thioxanthe-9-one |
| 1,2,3-Trichlorobenzene | Trichlorofluoromethane |
| 2,3,6-Trichlorophenol | 2,4,5-Trichlorophenol |
| 1,2,3-Trichloropropane | 1,2,3-Trimethoxybenzene |
| 2,4,5-Trimethylaniline | Triphenylene |
| Tripropyleneglycol Methyl Ether | Vinyl Acetate |

(a) Pollutant not detected in any untreated wastewater samples during EPA's 18 iron and steel sampling episodes.

Table 7-3

**Pollutants Not Identified as Pollutants of Concern
Cokemaking Subcategory - By-Product Recovery Segment (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|--|
| <i>Conventional Pollutants</i> | | | | |
| pH | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | | Chloride is not selected as a POC for any subcategory |
| Sulfate | | (e) | | Except where noted, sulfate is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | | TDS is not selected as a POC for any subcategory |
| Total Sulfide | | | | Total sulfide is not selected as a POC for any subcategory |
| <i>Priority Metals</i> | | | | |
| Antimony | | ✓ | | |
| Beryllium | | ✓ | ✓ | |
| Cadmium | | ✓ | | |
| Chromium | | ✓ | ✓ | |
| Copper | | ✓ | | |
| Lead | | ✓ | ✓ | |
| Nickel | | ✓ | ✓ | |
| Silver | ✓ | | | |
| Thallium | | ✓ | | |
| Zinc | | ✓ | ✓ | |
| <i>Nonconventional Metals</i> | | | | |
| Aluminum | | ✓ | ✓ | |
| Barium | | ✓ | ✓ | |
| Calcium | | ✓ | ✓ | Calcium is not selected as a POC for any subcategory |

Table 7-3 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Cobalt | | ✓ | ✓ | |
| Iron | | | ✓ | |
| Magnesium | | ✓ | ✓ | |
| Manganese | | ✓ | ✓ | |
| Molybdenum | ✓ | | | |
| Sodium | | | | Sodium is not selected as a POC for any subcategory |
| Tin | | ✓ | | |
| Titanium | | ✓ | ✓ | |
| Vanadium | ✓ | | | |
| Yttrium | ✓ | | | |
| <i>Priority Organic Pollutants</i> | | | | |
| Acrylonitrile | | ✓ | | |
| Bis(2-chloroethoxy)methane | | ✓ | | |
| Bis(2-chloroethyl) Ether | | ✓ | | |
| Bis(2-ethylhexyl) Phthalate | | ✓ | | |
| Chloroform | ✓ | | | |
| 4-Chloro-3-methylphenol | | ✓ | | |
| Dibenzo(a,h)anthracene | ✓ | | | |
| Dibromochloromethane | ✓ | | | |
| trans-1,3-Dichloropropene | | ✓ | | |
| 1,2-Diphenylhydrazine | ✓ | | | |
| Methylene Chloride | ✓ | | | |
| Nitrobenzene | | ✓ | | |
| 2-Nitrophenol | ✓ | | | |
| 4-Nitrophenol | ✓ | | | |
| N-Nitrosodiphenylamine | ✓ | | | |
| Tribromomethane | ✓ | | | |

Table 7-3 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| 1,1,1-Trichloroethane | ✓ | | | |
| Trichloroethene | ✓ | | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetophenone | ✓ | | | |
| alpha-Terpineol | ✓ | | | |
| 4-Aminobiphenyl | ✓ | | | |
| Benzenethiol | | ✓ | | |
| Benzoic Acid | ✓ | | | |
| Benzyl Alcohol | ✓ | | | |
| n-Decane | ✓ | | | |
| 2,6-Di-tert-butyl-p-benzoquinone | ✓ | | | |
| N,N-Dimethylformamide | ✓ | | | |
| 3,6-Dimethylphenanthrene | ✓ | | | |
| Dimethyl Sulfone | ✓ | | | |
| 1,4-Dioxane | | ✓ | | |
| Diphenylamine | ✓ | | | |
| n-Docosane | ✓ | | | |
| n-Dodecane | ✓ | | | |
| n-Hexacosane | ✓ | | | |
| Hexanoic Acid | ✓ | | | |
| 1-Methylfluorene | | ✓ | | |
| n-Octacosane | ✓ | | | |
| Resorcinol | | ✓ | | |
| n-Tetracosane | ✓ | | | |
| n-Tetradecane | | ✓ | | |
| n-Triacontane | ✓ | | | |
| 1,3,5-Trithiane | | ✓ | | |

Table 7-3 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|---------------------------------|--|---|-----------------|
| <i>Priority Dioxin and Furans</i> | | | | |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | | ✓ | | |
| <i>Nonconventional Dioxins and Furans</i> | | | | |
| 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | ✓ | | | |
| 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | ✓ | | | |
| 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin | ✓ | | | |
| 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | ✓ | | | |
| 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | ✓ | | | |
| Octachlorodibenzo-p-dioxin | ✓ | | | |
| 2,3,7,8-Tetrachlorodibenzofuran | | ✓ | | |
| 1,2,3,7,8-Pentachlorodibenzofuran | ✓ | | | |
| 2,3,4,7,8-Pentachlorodibenzofuran | ✓ | | | |
| 1,2,3,4,7,8-Hexachlorodibenzofuran | ✓ | | | |
| 1,2,3,6,7,8-Hexachlorodibenzofuran | ✓ | | | |
| 1,2,3,7,8,9-Hexachlorodibenzofuran | ✓ | | | |
| 2,3,4,6,7,8-Hexachlorodibenzofuran | ✓ | | | |
| 1,2,3,4,6,7,8-Heptachlorodibenzofuran | ✓ | | | |

Table 7-3 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Dioxins and Furans (continued)</i> | | | | |
| 1,2,3,4,7,8,9- Heptachlorodibenzofuran | ✓ | | | |
| Octachlorodibenzofuran | ✓ | | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from this segment.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this segment.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals, nonconventional organic pollutants, and nonconventional dioxins and furans.

Table 7-4

Pollutants of Concern
Cokemaking Subcategory - By-Product Recovery Segment

| Pollutant Group | Pollutant of Concern |
|---------------------------------------|---|
| Conventional pollutants | Biochemical oxygen demand 5-day (BOD ₅) |
| | Biochemical oxygen demand 5-day (BOD ₅) - carbonaceous |
| | Oil and grease measured as hexane extractable material (HEM) |
| | Total suspended solids (TSS) |
| Nonconventional pollutants, other (a) | Amenable cyanide |
| | Ammonia as nitrogen |
| | Chemical oxygen demand (COD) |
| | Fluoride |
| | Nitrate/nitrite |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) |
| | Thiocyanate |
| | Total Kjeldahl nitrogen (TKN) |
| | Total organic carbon (TOC) |
| | Total phenols |
| | Weak acid dissociable (WAD) cyanide |
| Priority metals | Arsenic |
| | Mercury |
| | Selenium |
| Nonconventional metals | Boron |
| Priority organic pollutants | Acenaphthene |
| | Acenaphthylene |
| | Anthracene |
| | Benzene |
| | Benzidine |
| | Benzo(a)anthracene |
| | Benzo(a)pyrene |
| | Benzo(b)fluoranthene |
| | Benzo(k)fluoranthene |
| | Benzo(ghi)perylene |
| | Chrysene |

Table 7-4 (Continued)

| Pollutant Group | Pollutant of Concern |
|-------------------------------------|-----------------------------|
| Priority organic pollutants (cont.) | 1,2-Dichloroethane |
| | 2,4-Dimethylphenol |
| | Ethylbenzene |
| | Fluoranthene |
| | Fluorene |
| | Indeno(1,2,3-cd)pyrene |
| | Naphthalene |
| | Phenanthrene |
| | Phenol |
| | Pyrene |
| | Toluene |
| Nonconventional organic pollutants | Aniline |
| | 2,3-Benzofluorene |
| | beta-Naphthylamine |
| | Biphenyl |
| | 2-Butanone |
| | Carbazole |
| | Carbon disulfide |
| | Dibenzofuran |
| | Dibenzothiophene |
| | 4,5-Methylene phenanthrene |
| | 2-Methylnaphthalene |
| | 1-Methylphenanthrene |
| | m- + p-Xylene |
| | m-Xylene |
| | 1-Naphthylamine |
| | n-Eicosane |
| | n-Hexadecane |
| | n-Octadecane |
| | o-Cresol |
| | o- + p-Xylene |
| | o-Toluidine |
| | o-Xylene |

Table 7-4 (Continued)

| Pollutant Group | Pollutant of Concern |
|--|-----------------------------|
| Nonconventional organic pollutants (cont.) | p-Cresol |
| | Perylene |
| | 2-Phenylnaphthalene |
| | 2-Picoline |
| | 2-Propanone |
| | Pyridine |
| | Styrene |
| | Thianaphthene |
| Other priority pollutants | Total cyanide |

(a) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-5

**Pollutants Not Identified as Pollutants of Concern
Ironmaking Subcategory (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|--|
| <i>Conventional Pollutants</i> | | | | |
| pH (SU) | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | | Chloride is not selected as a POC for any subcategory |
| Sulfate | | (e) | | Except where noted, sulfate is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | | TDS is not selected as a POC for any subcategory |
| Total Sulfide | | ✓ | | Total sulfide is not selected as a POC for any subcategory |
| <i>Priority Metals</i> | | | | |
| Antimony | | ✓ | | |
| Beryllium | | ✓ | | |
| <i>Nonconventional Metals</i> | | | | |
| Barium | | ✓ | | |
| Calcium | | | | Calcium is not selected as a POC for any subcategory |
| Cobalt | | ✓ | | |
| Sodium | | | | Sodium is not selected as a POC for any subcategory |
| Tin | | ✓ | | |
| Vanadium | | ✓ | | |
| Yttrium | | ✓ | | |
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | ✓ | | | |
| Acenaphthylene | ✓ | | | |
| Acrylonitrile | ✓ | | | |
| Anthracene | BF | S | | |
| Benzene | ✓ | | | |

Table 7-5 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| Benzidine | ✓ | | | |
| Benzo(ghi)perylene | BF | S | | |
| Bis(2-chloroethoxy)methane | ✓ | | | |
| Bis(2-chloroethyl) Ether | ✓ | | | |
| Bis(2-ethylhexyl) Phthalate | | ✓ | | |
| Chloroform | S | BF | BF | |
| 4-Chloro-3-methylphenol | | ✓ | | |
| Dibenzo(a,h)anthracene | BF | S | | |
| Dibromochloromethane | ✓ | | | |
| 1,2-Dichloroethane | ✓ | | | |
| trans-1,3-Dichloropropene | ✓ | | | |
| 1,2-Diphenylhydrazine | ✓ | | | |
| Ethylbenzene | ✓ | | | |
| Fluorene | BF | S | | |
| Indeno(1,2,3-cd)pyrene | BF | S | | |
| Methylene Chloride | ✓ | | | |
| Naphthalene | S | BF | | |
| Nitrobenzene | ✓ | | | |
| 2-Nitrophenol | BF | S | | |
| N-Nitrosodiphenylamine | ✓ | | | |
| Toluene | ✓ | | | |
| Tribromomethane | ✓ | | | |
| 1,1,1-Trichloroethane | ✓ | | | |
| Trichloroethene | ✓ | | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetone | | ✓ | | |
| Acetophenone | ✓ | | | |
| alpha-Terpineol | ✓ | | | |
| 4-Aminobiphenyl | BF | S | | |

Table 7-5 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| Aniline | ✓ | | | |
| Benzenethiol | ✓ | | | |
| 2,3-Benzofluorene | BF | S | | |
| Benzoic Acid | BF | S | | |
| Benzyl Alcohol | BF | S | | |
| Biphenyl | ✓ | | | |
| Carbazole | BF | S | | |
| Carbon Disulfide | ✓ | | | |
| n-Decane | ✓ | | | |
| Dibenzofuran | BF | S | | |
| Dibenzothiophene | BF | S | | |
| 2,6-Di-tert-butyl-p-benzoquinone | ✓ | | | |
| N,N-Dimethylformamide | BF | S | | |
| 3,6-Dimethylphenanthrene | BF | S | | |
| Dimethyl Sulfone | BF | S | | |
| 1,4-Dioxane | ✓ | | | |
| Diphenylamine | ✓ | | | |
| n-Dodecane | BF | S | | |
| n-Hexacosane | BF | S | | |
| Hexanoic Acid | | ✓ | ✓ | |
| Methyl Ethyl Ketone | ✓ | | | |
| 4,5-Methylene Phenanthrene | ✓ | | | |
| 1-Methylfluorene | ✓ | | | |
| 2-Methylnaphthalene | BF | S | | |
| 1-Methylphenanthrene | BF | S | | |
| alpha-Naphthylamine | ✓ | | | |
| beta-Naphthylamine | ✓ | | | |
| n-Octacosane | BF | S | | |
| Perylene | ✓ | | | |

Table 7-5 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| 2-Phenylnaphthalene | ✓ | | | |
| 2-Picoline | ✓ | | | |
| Resorcinol | ✓ | | | |
| Styrene | ✓ | | | |
| n-Tetradecane | BF | S | | |
| Thianaphthene | ✓ | | | |
| o-Toluidine | S | BF | | |
| n-Triacontane | BF | S | | |
| 1,3,5-Trithiane | ✓ | | | |
| m-Xylene | ✓ | | | |
| m- + p-Xylene | ✓ | | | |
| o-Xylene | ✓ | | | |
| o- + p-Xylene | ✓ | | | |
| <i>Priority Dioxins and Furans</i> | | | | |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | | ✓ | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from all segments/operations within the subcategory, while letter codes indicate the specific segment/operation which correspond to the criterium. The following letter codes apply: BF- blast furnace ironmaking; S - sintering.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this subcategory.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-6

Pollutants of Concern
Ironmaking Subcategory - Sintering Segment

| Pollutant Group | Pollutant of Concern |
|---------------------------------------|---|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) |
| | Total suspended solids (TSS) |
| Nonconventional pollutants, other (a) | Amenable cyanide |
| | Ammonia as nitrogen |
| | Chemical oxygen demand (COD) |
| | Fluoride |
| | Nitrate/nitrite |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) |
| | Thiocyanate |
| | Total Kjeldahl nitrogen (TKN) |
| | Total organic carbon (TOC) |
| | Total phenols |
| | Weak acid dissociable (WAD) cyanide |
| Priority metals | Arsenic |
| | Cadmium |
| | Chromium |
| | Copper |
| | Lead |
| | Mercury |
| | Selenium |
| | Silver |
| | Thallium |
| | Zinc |
| Nonconventional metals | Aluminum |
| | Boron |
| | Iron |
| | Magnesium |
| | Manganese |
| | Titanium |

Table 7-6 (Continued)

| Pollutant Group | Pollutant of Concern |
|------------------------------------|---|
| Priority organic pollutants | Benzo(a)anthracene |
| | Benzo(a)pyrene |
| | Benzo(b)fluoranthene |
| | Benzo(k)fluoranthene |
| | Chrysene |
| | 2,4-Dimethylphenol |
| | Fluoranthene |
| | 4-Nitrophenol |
| | Phenanthrene |
| | Phenol |
| | Pyrene |
| Nonconventional organic pollutants | n-Docosane |
| | n-Eicosane |
| | n-Hexadecane |
| | n-Octadecane |
| | n-Tetracosane |
| | o-Cresol |
| | p-Cresol |
| | Pyridine |
| Nonconventional dioxins and furans | 1,2,3,4,6,7,8-Heptachlorodibenzofuran |
| | 1,2,3,4,7,8,9-Heptachlorodibenzofuran |
| | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin |
| | 1,2,3,4,7,8-Hexachlorodibenzofuran |
| | 1,2,3,6,7,8-Hexachlorodibenzofuran |
| | 1,2,3,7,8,9-Hexachlorodibenzofuran |
| | 2,3,4,6,7,8-Hexachlorodibenzofuran |
| | 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin |
| | 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin |
| | 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin |
| | Octachlorodibenzofuran |
| | Octachlorodibenzo-p-dioxin |
| | 1,2,3,7,8-Pentachlorodibenzofuran |
| | 2,3,4,7,8-Pentachlorodibenzofuran |

Table 7-6 (Continued)

| Pollutant Group | Pollutant of Concern |
|--|---------------------------------------|
| Nonconventional dioxins and furans (cont.) | 1,2,3,7,8-Pentachlorodibenzo-p-dioxin |
| | 2,3,7,8-Tetrachlorodibenzofuran |
| Other priority pollutants | Total cyanide |

(a) Nonconventional pollutants other than nonconventional metals, nonconventional organic pollutants, and nonconventional dioxins and furans.

Table 7-7

Pollutants of Concern
Ironmaking Subcategory - Blast Furnace Segment

| Pollutant Group | Pollutant of Concern |
|---------------------------------------|---|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) |
| | Total suspended solids (TSS) |
| Nonconventional pollutants, other (a) | Amenable cyanide |
| | Ammonia as nitrogen |
| | Chemical oxygen demand (COD) |
| | Fluoride |
| | Nitrate/nitrite |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) |
| | Thiocyanate |
| | Total Kjeldahl nitrogen (TKN) |
| | Total organic carbon (TOC) |
| | Weak acid dissociable (WAD) cyanide |
| Priority metals | Chromium |
| | Copper |
| | Lead |
| | Nickel |
| | Selenium |
| | Zinc |
| Nonconventional metals | Aluminum |
| | Boron |
| | Iron |
| | Magnesium |
| | Manganese |
| | Molybdenum |
| | Titanium |
| Nonconventional dioxins and furans | 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin |
| Other priority pollutants | Total cyanide |

(a) Nonconventional pollutants other than nonconventional metals and nonconventional dioxins and furans.

Table 7-8

**Pollutants Not Identified as Pollutants of Concern
Integrated Steelmaking Subcategory (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|---|
| <i>Conventional Pollutants</i> | | | | |
| pH (SU) | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | | Except where noted, chloride is not selected as a POC for any subcategory |
| Sulfate | | (e) | | Except where noted, sulfate is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | | Except where noted, TDS is not selected as a POC for any subcategory |
| Total Kjeldahl Nitrogen (TKN) | | (e) | VD, CC | |
| Total Recoverable Phenolics | VD, CC | BOF | | |
| <i>Priority Metals</i> | | | | |
| Arsenic | | ✓ | | |
| Selenium | VD | BOF | CC | |
| Thallium | | ✓ | | |
| <i>Nonconventional Metals</i> | | | | |
| Aluminum, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Antimony, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Arsenic, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Barium | | ✓ | | |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Barium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Beryllium, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Boron | | ✓ | | |
| Boron, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Calcium | | | VD | Except where noted, calcium is not selected as a POC for any subcategory |
| Calcium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Chromium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Copper, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Iron, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Lead, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Magnesium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Manganese, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Mercury, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Molybdenum, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Nickel, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Selenium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Sodium | | | | Except where noted, sodium is not selected as a POC for any subcategory |
| Sodium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Titanium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Yttrium | VD | BOF, CC | | |
| Yttrium, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Zinc, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | ✓ | | | |
| Acenaphthylene | ✓ | | | |
| Acrylonitrile | ✓ | | | |
| Anthracene | ✓ | | | |
| Benzene | ✓ | | | |
| Benzidine | ✓ | | | |
| Benzo(a)anthracene | ✓ | | | |
| Benzo(b)fluoranthene | ✓ | | | |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|---------------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| Benzo(k)fluoranthene | ✓ | | | |
| Benzo(ghi)perylene | ✓ | | | |
| Benzo(a)pyrene | ✓ | | | |
| Bis(2-chloroethoxy)methane | ✓ | | | |
| Bis(2-chloroethyl) Ether | ✓ | | | |
| Bis(2-ethylhexyl) Phthalate | ✓ | | | |
| Chloroform | ✓ | | | |
| 4-Chloro-3-methylphenol | ✓ | | | |
| Chrysene | ✓ | | | |
| Dibenzo(a,h)anthracene | ✓ | | | |
| Dibromochloromethane | ✓ | | | |
| 1,2-Dichloroethane | ✓ | | | |
| trans-1,3-Dichloropropene | ✓ | | | |
| 2,4-Dimethylphenol | VD, CC | BOF | | |
| 1,2-Diphenylhydrazine | ✓ | | | |
| Ethylbenzene | ✓ | | | |
| Fluoranthene | ✓ | | | |
| Fluorene | ✓ | | | |
| Indeno(1,2,3-cd)pyrene | ✓ | | | |
| Methylene Chloride | ✓ | | | |
| Naphthalene | VD, CC | BOF | | |
| Nitrobenzene | ✓ | | | |
| 2-Nitrophenol | VD, CC | BOF | | |
| 4-Nitrophenol | ✓ | | | |
| N-Nitrosodiphenylamine | ✓ | | | |
| Phenanthrene | ✓ | | | |
| Pyrene | ✓ | | | |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| Toluene | ✓ | | | |
| Tribromomethane | ✓ | | | |
| 1,1,1-Trichloroethane | ✓ | | | |
| Trichloroethene | VD, CC | BOF | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetone | VD, CC | BOF | | |
| Acetophenone | ✓ | | | |
| alpha-Terpineol | ✓ | | | |
| 4-Aminobiphenyl | ✓ | | | |
| Aniline | ✓ | | | |
| Benzenethiol | ✓ | | | |
| 2,3-Benzofluorene | ✓ | | | |
| Benzoic Acid | ✓ | | | |
| Benzyl Alcohol | ✓ | | | |
| Biphenyl | ✓ | | | |
| Carbazole | ✓ | | | |
| Carbon Disulfide | ✓ | | | |
| o-Cresol | VD, CC | BOF | | |
| p-Cresol | VD, CC | BOF | | |
| n-Decane | ✓ | | | |
| Dibenzofuran | ✓ | | | |
| Dibenzothiophene | ✓ | | | |
| 2,6-Di-tert-butyl-p-benzoquinone | ✓ | | | |
| N,N-Dimethylformamide | ✓ | | | |
| 3,6-Dimethylphenanthrene | ✓ | | | |
| Dimethyl Sulfone | ✓ | | | |
| 1,4-Dioxane | ✓ | | | |
| Diphenylamine | ✓ | | | |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| n-Docosane | ✓ | | | |
| n-Dodecane | ✓ | | | |
| n-Eicosane | ✓ | | | |
| n-Hexacosane | ✓ | | | |
| n-Hexadecane | ✓ | | | |
| Hexanoic Acid | ✓ | | | |
| Methyl Ethyl Ketone | ✓ | | | |
| 4,5-Methylene Phenanthrene | ✓ | | | |
| 1-Methylfluorene | ✓ | | | |
| 2-Methylnaphthalene | ✓ | | | |
| 1-Methylphenanthrene | ✓ | | | |
| alpha-Naphthylamine | ✓ | | | |
| beta-Naphthylamine | ✓ | | | |
| n-Octacosane | ✓ | | | |
| n-Octadecane | ✓ | | | |
| Perylene | ✓ | | | |
| 2-Phenylnaphthalene | ✓ | | | |
| 2-Picoline | ✓ | | | |
| Pyridine | VD, CC | BOF | | |
| Resorcinol | ✓ | | | |
| Styrene | VD, CC | BOF | | |
| n-Tetracosane | ✓ | | | |
| n-Tetradecane | ✓ | | | |
| Thianaphthene | ✓ | | | |
| o-Toluidine | ✓ | | | |
| n-Triacontane | ✓ | | | |
| 1,3,5-Trithiane | ✓ | | | |
| m-Xylene | ✓ | | | |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| m- + p-Xylene | ✓ | | | |
| o-Xylene | ✓ | | | |
| o- + p-Xylene | ✓ | | | |
| <i>Priority Dioxins and Furans</i> | | | | |
| 2,3,7,8- Tetrachlorodibenzo-p- dioxin | BOF | | | |
| <i>Nonconventional Dioxins and Furans</i> | | | | |
| 1,2,3,7,8- Pentachlorodibenzo-p- dioxin | BOF | | | |
| 1,2,3,4,7,8- Hexachlorodibenzo-p- dioxin | BOF | | | |
| 1,2,3,6,7,8- Hexachlorodibenzo-p- dioxin | BOF | | | |
| 1,2,3,7,8,9- Hexachlorodibenzo-p- dioxin | BOF | | | |
| 1,2,3,4,6,7,8- Heptachlorodibenzo-p- dioxin | BOF | | | |
| Octachlorodibenzo-p- dioxin | | BOF | BOF | |
| 2,3,7,8- Tetrachlorodibenzofuran | | BOF | | |
| 1,2,3,7,8- Pentachlorodibenzofuran | BOF | | | |
| 2,3,4,7,8- Pentachlorodibenzofuran | BOF | | | |
| 1,2,3,4,7,8- Hexachlorodibenzofuran | BOF | | | |
| 1,2,3,6,7,8- Hexachlorodibenzofuran | BOF | | | |

Table 7-8 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|-----------------|
| <i>Nonconventional Dioxins and Furans (continued)</i> | | | | |
| 1,2,3,7,8,9-Hexachlorodibenzofuran | BOF | | | |
| 2,3,4,6,7,8-Hexachlorodibenzofuran | BOF | | | |
| 1,2,3,4,6,7,8-Heptachlorodibenzofuran | BOF | | | |
| 1,2,3,4,7,8,9-Heptachlorodibenzofuran | BOF | | | |
| Octachlorodibenzofuran | BOF | | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from all segments/operations within the subcategory, while letter codes indicate the specific segment/operation which correspond to the criterium. The following letter codes apply: BOF - basic oxygen furnace steelmaking; VD - vacuum degassing; CC - continuous casting.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this subcategory.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals, nonconventional organic pollutants, and nonconventional dioxins and furans.

Table 7-9

Pollutants of Concern
Integrated Steelmaking Subcategory

| Pollutant Group | Pollutant of Concern | BOF Steelmaking | Vacuum Degassing | Continuous Casting |
|---------------------------------------|---|----------------------------|-----------------------------|-------------------------------|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) | ✓ | ✓ | ✓ |
| | Total suspended solids (TSS) | ✓ | ✓ | ✓ |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen | ✓ | ✓ | |
| | Chemical oxygen demand (COD) | ✓ | ✓ | ✓ |
| | Fluoride | ✓ | ✓ | ✓ |
| | Nitrate/nitrite | ✓ | | |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | ✓ | ✓ | ✓ |
| | Total organic carbon (TOC) | ✓ | | ✓ |
| Priority metals | Antimony | ✓ | | ✓ |
| | Beryllium | ✓ | | |
| | Cadmium | ✓ | | |
| | Chromium | ✓ | | |
| | Copper | ✓ | ✓ | |
| | Lead | ✓ | ✓ | ✓ |
| | Mercury | ✓ | | |
| | Nickel | ✓ | | |
| | Silver | ✓ | | |
| | Zinc | ✓ | ✓ | ✓ |
| Nonconventional metals | Aluminum | ✓ | ✓ | ✓ |
| | Cobalt | ✓ | | |
| | Iron | ✓ | ✓ | ✓ |
| | Magnesium | ✓ | | |
| | Manganese | ✓ | ✓ | ✓ |
| | Molybdenum | ✓ | ✓ | ✓ |
| | Tin | ✓ | ✓ | |
| | Titanium | ✓ | ✓ | |
| | Vanadium | ✓ | | |
| Priority organic pollutants | Phenol | ✓ | | |

(a) Nonconventional pollutants other than nonconventional metals.

Table 7-10

**Pollutants Not Identified as Pollutants of Concern
Integrated and Stand-Alone Hot Forming Subcategory (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|-----------------------------|--|---|--|
| <i>Conventional Pollutants</i> | | | | |
| pH (SU) | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | ✓ | Chloride is not selected as a POC for any subcategory |
| Nitrate/Nitrite (NO ₂ + NO ₃ -N) | | ✓ | ✓ | |
| Sulfate | | (e) | | Except where noted, sulfate is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | ✓ | TDS is not selected as a POC for any subcategory |
| Total Kjeldahl Nitrogen (TKN) | | (e) | ✓ | |
| Total Recoverable Phenolics | ✓ | | | |
| <i>Priority Metals</i> | | | | |
| Arsenic | | ✓ | | |
| Beryllium | ✓ | | | |
| Cadmium | ✓ | | | |
| Mercury | | ✓ | | |
| Selenium | | ✓ | | |
| Silver | | ✓ | ✓ | |
| Thallium | | ✓ | | |
| <i>Nonconventional Metals</i> | | | | |
| Aluminum | | ✓ | ✓ | |
| Barium | | ✓ | ✓ | |
| Boron | | ✓ | ✓ | |
| Calcium | | | ✓ | Calcium is not selected as a POC for any subcategory |
| Cobalt | ✓ | | | |

Table 7-10 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Magnesium | | ✓ | ✓ | |
| Sodium | | | ✓ | Sodium is not selected as a POC for any subcategory |
| Tin | | ✓ | | |
| Vanadium | | ✓ | | |
| Yttrium | ✓ | | | |
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | ✓ | | | |
| Acenaphthylene | ✓ | | | |
| Acrylonitrile | ✓ | | | |
| Anthracene | ✓ | | | |
| Benzene | ✓ | | | |
| Benzidine | ✓ | | | |
| Benzo(a)anthracene | ✓ | | | |
| Benzo(b)fluoranthene | ✓ | | | |
| Benzo(k)fluoranthene | ✓ | | | |
| Benzo(ghi)perylene | ✓ | | | |
| Benzo(a)pyrene | ✓ | | | |
| Bis(2-chloroethoxy)methane | ✓ | | | |
| Bis(2-chloroethyl) Ether | ✓ | | | |
| Bis(2-ethylhexyl) Phthalate | ✓ | | | |
| Chloroform | ✓ | | | |
| 4-Chloro-3-methylphenol | ✓ | | | |
| Chrysene | ✓ | | | |
| Dibenzo(a,h)anthracene | ✓ | | | |
| Dibromochloromethane | ✓ | | | |
| 1,2-Dichloroethane | ✓ | | | |
| trans-1,3-Dichloropropene | ✓ | | | |
| 2,4-Dimethylphenol | ✓ | | | |

Table 7-10 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| 1,2-Diphenylhydrazine | ✓ | | | |
| Ethylbenzene | ✓ | | | |
| Fluoranthene | ✓ | | | |
| Fluorene | ✓ | | | |
| Indeno(1,2,3-cd)pyrene | ✓ | | | |
| Methylene Chloride | ✓ | | | |
| Naphthalene | ✓ | | | |
| Nitrobenzene | ✓ | | | |
| 2-Nitrophenol | ✓ | | | |
| 4-Nitrophenol | ✓ | | | |
| N-Nitrosodiphenylamine | ✓ | | | |
| Phenanthrene | ✓ | | | |
| Phenol | ✓ | | | |
| Pyrene | ✓ | | | |
| Toluene | ✓ | | | |
| Tribromomethane | ✓ | | | |
| 1,1,1-Trichloroethane | ✓ | | | |
| Trichloroethene | ✓ | | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetone | | ✓ | | |
| Acetophenone | ✓ | | | |
| alpha-Terpineol | ✓ | | | |
| 4-Aminobiphenyl | ✓ | | | |
| Aniline | ✓ | | | |
| Benzenethiol | ✓ | | | |
| 2,3-Benzofluorene | ✓ | | | |
| Benzoic Acid | ✓ | | | |
| Benzyl Alcohol | ✓ | | | |
| Biphenyl | ✓ | | | |
| Carbazole | ✓ | | | |
| Carbon Disulfide | ✓ | | | |

Table 7-10 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| o-Cresol | ✓ | | | |
| p-Cresol | ✓ | | | |
| n-Decane | ✓ | | | |
| Dibenzofuran | ✓ | | | |
| Dibenzothiophene | ✓ | | | |
| 2,6-Di-tert-butyl-p-benzoquinone | ✓ | | | |
| N,N-Dimethylformamide | ✓ | | | |
| 3,6-Dimethylphenanthrene | ✓ | | | |
| Dimethyl Sulfone | ✓ | | | |
| 1,4-Dioxane | ✓ | | | |
| Diphenylamine | ✓ | | | |
| n-Docosane | ✓ | | | |
| n-Dodecane | ✓ | | | |
| n-Eicosane | ✓ | | | |
| n-Hexacosane | ✓ | | | |
| n-Hexadecane | ✓ | | | |
| Hexanoic Acid | ✓ | | | |
| Methyl Ethyl Ketone | ✓ | | | |
| 4,5-Methylene Phenanthrene | ✓ | | | |
| 1-Methylfluorene | ✓ | | | |
| 2-Methylnaphthalene | ✓ | | | |
| 1-Methylphenanthrene | ✓ | | | |
| alpha-Naphthylamine | ✓ | | | |
| beta-Naphthylamine | ✓ | | | |
| n-Octacosane | ✓ | | | |
| n-Octadecane | ✓ | | | |
| Perylene | ✓ | | | |
| 2-Phenylnaphthalene | ✓ | | | |
| 2-Picoline | ✓ | | | |

Table 7-10 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| Pyridine | ✓ | | | |
| Resorcinol | ✓ | | | |
| Styrene | ✓ | | | |
| n-Tetracosane | ✓ | | | |
| n-Tetradecane | ✓ | | | |
| Thianaphthene | ✓ | | | |
| o-Toluidine | ✓ | | | |
| n-Triacontane | ✓ | | | |
| 1,3,5-Trithiane | ✓ | | | |
| m-Xylene | ✓ | | | |
| m- + p-Xylene | ✓ | | | |
| o-Xylene | ✓ | | | |
| o- + p-Xylene | ✓ | | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from integrated and stand-alone hot forming operations on carbon and alloy steel. EPA did not sample integrated and stand-alone hot forming operations for stainless steelmaking operations; therefore, data on this table only apply to the integrated and stand-alone hot forming subcategory, carbon and alloy steel segment.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this subcategory.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-11

Pollutants of Concern
Integrated and Stand-Alone Hot Forming Subcategory
Carbon and Alloy Steel Segment

| Pollutant Group | Pollutant of Concern |
|---------------------------------------|---|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) |
| | Total suspended solids (TSS) |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen |
| | Chemical oxygen demand (COD) |
| | Fluoride |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) |
| Priority metals | Lead |
| | Zinc |
| Nonconventional metals | Iron |
| | Manganese |
| | Molybdenum |

(a) Nonconventional pollutants other than nonconventional metals.

Table 7-12

Pollutants of Concern
Integrated and Stand-Alone Hot Forming Subcategory
Stainless Steel Segment

| Pollutant Group | Pollutant of Concern |
|---------------------------------------|---|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) |
| | Total suspended solids (TSS) |
| Nonconventional pollutants, other (a) | Chemical oxygen demand (COD) |
| | Fluoride |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) |
| | Total organic carbon (TOC) |
| Priority metals | Antimony |
| | Chromium |
| | Copper |
| | Nickel |
| | Zinc |
| Nonconventional metals | Iron |
| | Manganese |
| | Molybdenum |
| | Titanium |

(a) Nonconventional pollutants other than nonconventional metals.

Table 7-13

**Pollutants Not Identified as Pollutants of Concern
Non-integrated Steelmaking and Hot Forming Subcategory (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|---|
| <i>Conventional Pollutants</i> | | | | |
| pH (SU) | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | | Except where noted, chloride is not selected as a POC for any subcategory |
| Sulfate | | (e) | | Except where noted, sulfate is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | | Except where noted, TDS is not selected as a POC for any subcategory |
| Total Kjeldahl Nitrogen (TKN) | | (e) | | |
| Total Recoverable Phenolics | | ✓ | | |
| <i>Priority Metals</i> | | | | |
| Arsenic | | ✓ | | |
| Beryllium | ✓ | | | |
| Cadmium | CC-S, HF-S, HF-C | CC-C | | |
| Mercury | ✓ | | | |
| Selenium | HF-C | CC-S, HF-S, CC-C | | |
| Silver | CC-S, HF-S, HF-C | CC-C | | |
| Thallium | CC-S, CC-C, HF-C | HF-S | | |

Table 7-13 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|-------------------------------|-----------------------------|--|---|---|
| <i>Nonconventional Metals</i> | | | | |
| Aluminum, Dissolved | CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Antimony, Dissolved | CC-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Arsenic, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Barium | | HF-S, CC-S, CC-C, HF-C | CC-S | |
| Barium, Dissolved | | (e) | CC-S, CC-C, HF-C | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Beryllium, Dissolved | CC-S, CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Boron, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Calcium | | CC-S | CC-S | Except where noted, calcium is not selected as a POC for any subcategory |
| Calcium, Dissolved | | (e) | CC-S | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Chromium, Dissolved | HF-C | (e) | HF-S | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Cobalt | CC-C | CC-S, HF-S, HF-C | | |
| Copper, Dissolved | HF-S, CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Iron, Dissolved | | (e) | CC-C, HF-C | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |

Table 7-13 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Lead, Dissolved | CC-S, HF-S, HF-C | (e) | CC-C | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Magnesium | | ✓ | | |
| Magnesium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Manganese, Dissolved | | (e) | CC-C, HF-C | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Mercury, Dissolved | CC-S, HF-S, CC-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Molybdenum, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Nickel, Dissolved | CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Selenium, Dissolved | CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Sodium | | | | Except where noted, sodium is not selected as a POC for any subcategory |
| Sodium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Tin | HF-S, HF-C | CC-S, CC-C | | |
| Titanium, Dissolved | HF-S, CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Vanadium | HF-S | CC-S, CC-C, HF-C | | |
| Yttrium | CC-S, CC-C, HF-C | HF-S | HF-S | |

Table 7-13 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Yttrium, Dissolved | HF-S, CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Zinc, Dissolved | CC-S, CC-C, HF-C | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | ✓ | | | |
| Acenaphthylene | ✓ | | | |
| Acrylonitrile | ✓ | | | |
| Anthracene | ✓ | | | |
| Benzene | ✓ | | | |
| Benzidine | ✓ | | | |
| Benzo(a)anthracene | ✓ | | | |
| Benzo(b)fluoranthene | ✓ | | | |
| Benzo(k)fluoranthene | ✓ | | | |
| Benzo(ghi)perylene | ✓ | | | |
| Benzo(a)pyrene | ✓ | | | |
| Bis(2-chloroethoxy)methane | ✓ | | | |
| Bis(2-chloroethyl) Ether | ✓ | | | |
| Bis(2-ethylhexyl) Phthalate | ✓ | | | |
| Chloroform | ✓ | | | |
| 4-Chloro-3-methylphenol | ✓ | | | |
| Chrysene | ✓ | | | |
| Dibenzo(a,h)anthracene | ✓ | | | |
| Dibromochloromethane | HF-S, CC-C, HF-C | CC-S | | |
| 1,2-Dichloroethane | ✓ | | | |
| trans-1,3-Dichloropropene | ✓ | | | |
| 2,4-Dimethylphenol | ✓ | | | |

Table 7-13 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| 1,2-Diphenylhydrazine | ✓ | | | |
| Ethylbenzene | ✓ | | | |
| Fluoranthene | ✓ | | | |
| Fluorene | ✓ | | | |
| Indeno(1,2,3-cd)pyrene | ✓ | | | |
| Methylene Chloride | ✓ | | | |
| Naphthalene | ✓ | | | |
| Nitrobenzene | ✓ | | | |
| 2-Nitrophenol | ✓ | | | |
| 4-Nitrophenol | ✓ | | | |
| N-Nitrosodiphenylamine | ✓ | | | |
| Phenanthrene | ✓ | | | |
| Phenol | ✓ | | | |
| Pyrene | ✓ | | | |
| Toluene | ✓ | | | |
| 1,1,1-Trichloroethane | ✓ | | | |
| Trichloroethene | ✓ | | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetone | CC-C, HF-C | CC-S, HF-S | | |
| Acetophenone | ✓ | | | |
| alpha-Terpineol | ✓ | | | |
| 4-Aminobiphenyl | ✓ | | | |
| Aniline | ✓ | | | |
| Benzenethiol | ✓ | | | |
| 2,3-Benzofluorene | ✓ | | | |
| Benzoic Acid | HF-C | CC-S, HF-S, CC-C | | |
| Benzyl Alcohol | HF-S | CC-S, CC-C, HF-C | | |
| Biphenyl | ✓ | | | |
| Carbazole | ✓ | | | |

Table 7-13 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| Carbon Disulfide | ✓ | | | |
| o-Cresol | ✓ | | | |
| p-Cresol | ✓ | | | |
| n-Decane | ✓ | | | |
| Dibenzofuran | ✓ | | | |
| Dibenzothiophene | ✓ | | | |
| 2,6-Di-tert-butyl-p-benzoquinone | ✓ | | | |
| N,N-Dimethylformamide | ✓ | | | |
| 3,6-Dimethylphenanthrene | ✓ | | | |
| Dimethyl Sulfone | ✓ | | | |
| 1,4-Dioxane | ✓ | | | |
| Diphenylamine | ✓ | | | |
| n-Docosane | ✓ | | | |
| n-Dodecane | ✓ | | | |
| n-Eicosane | ✓ | | | |
| n-Hexacosane | ✓ | | | |
| n-Hexadecane | ✓ | | | |
| Hexanoic Acid | ✓ | | | |
| Methyl Ethyl Ketone | ✓ | | | |
| 4,5-Methylene Phenanthrene | ✓ | | | |
| 1-Methylfluorene | ✓ | | | |
| 2-Methylnaphthalene | ✓ | | | |
| 1-Methylphenanthrene | ✓ | | | |
| alpha-Naphthylamine | ✓ | | | |
| beta-Naphthylamine | ✓ | | | |
| n-Octacosane | ✓ | | | |
| n-Octadecane | ✓ | | | |
| Perylene | ✓ | | | |

Table 7-13 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| 2-Phenylnaphthalene | ✓ | | | |
| 2-Picoline | ✓ | | | |
| Pyridine | ✓ | | | |
| Resorcinol | ✓ | | | |
| Styrene | ✓ | | | |
| n-Tetracosane | ✓ | | | |
| n-Tetradecane | ✓ | | | |
| Thianaphthene | ✓ | | | |
| o-Toluidine | ✓ | | | |
| n-Triacontane | ✓ | | | |
| 1,3,5-Trithiane | ✓ | | | |
| m-Xylene | ✓ | | | |
| m- + p-Xylene | ✓ | | | |
| o-Xylene | ✓ | | | |
| o- + p-Xylene | ✓ | | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from all segments/operations within the subcategory, while letter codes indicate the specific segment/operation which correspond to the criterium. The following letter codes apply: CC-S - continuous casting, stainless steel; HF-S - hot forming, stainless steel; CC-C - continuous casting, carbon and alloy steel; HF-C - hot forming, carbon and alloy steel.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this subcategory.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-14

Pollutants of Concern
Non-Integrated Steelmaking and Hot Forming Subcategory
Carbon and Alloy Steel Segment

| Pollutant Group | Pollutant of Concern | Continuous Casting | Hot Forming |
|---------------------------------------|---|---------------------------|--------------------|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) | ✓ | ✓ |
| | Total suspended solids (TSS) | ✓ | ✓ |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen | ✓ | ✓ |
| | Chemical oxygen demand (COD) | ✓ | ✓ |
| | Fluoride | ✓ | ✓ |
| | Nitrate/nitrite | | ✓ |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | ✓ | ✓ |
| | Total organic carbon (TOC) | ✓ | ✓ |
| Priority metals | Copper | ✓ | |
| | Lead | ✓ | ✓ |
| | Zinc | ✓ | ✓ |
| Nonconventional metals | Boron | ✓ | |
| | Iron | ✓ | ✓ |
| | Manganese | ✓ | ✓ |
| | Molybdenum | ✓ | ✓ |

(a) Nonconventional pollutants other than nonconventional metals.

Note: EPA did not identify POCs for vacuum degassing because EPA did not sample non-integrated vacuum degassing operations during its sampling program. POCs identified for continuous casting and hot forming apply to vacuum degassing.

Table 7-15

Pollutants of Concern
Non-Integrated Steelmaking and Hot Forming Subcategory
Stainless Steel Segment

| Pollutant Group | Pollutant of Concern | Continuous Casting | Hot Forming |
|---------------------------------------|---|---------------------------|--------------------|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) | ✓ | ✓ |
| | Total suspended solids (TSS) | ✓ | ✓ |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen | ✓ | |
| | Chemical oxygen demand (COD) | ✓ | ✓ |
| | Fluoride | ✓ | ✓ |
| | Nitrate/nitrite | ✓ | |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | ✓ | ✓ |
| | Total organic carbon (TOC) | ✓ | ✓ |
| Priority metals | Antimony | | ✓ |
| | Chromium | ✓ | ✓ |
| | Copper | ✓ | ✓ |
| | Lead | ✓ | |
| | Nickel | ✓ | ✓ |
| | Zinc | ✓ | ✓ |
| Nonconventional metals | Aluminum | ✓ | |
| | Boron | ✓ | |
| | Hexavalent chromium | ✓ | |
| | Iron | ✓ | ✓ |
| | Manganese | ✓ | ✓ |
| | Molybdenum | ✓ | ✓ |
| | Titanium | ✓ | ✓ |
| Priority organic pollutants | Tribromomethane | ✓ | |

(a) Nonconventional pollutants other than nonconventional metals.

Note: EPA did not identify POCs for vacuum degassing because EPA did not sample non-integrated vacuum degassing operations during its sampling program. POCs identified for continuous casting and hot forming apply to vacuum degassing.

Table 7-16

**Pollutants Not Identified as Pollutants of Concern
Steel Finishing Subcategory (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|---|
| <i>Conventional Pollutants</i> | | | | |
| pH (SU) | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | ✓ | Chloride is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | ✓ | TDS is not selected as a POC for any subcategory |
| Total Kjeldahl Nitrogen (TKN) | ✓ | (e) | | |
| <i>Priority Metals</i> | | | | |
| Beryllium | ✓ | ✓ | | |
| Mercury | ✓ | ✓ | | |
| Silver | ✓ | ✓ | ✓ | |
| Thallium | ✓ | ✓ | | |
| <i>Nonconventional Metals</i> | | | | |
| Calcium | | ✓ | ✓ | Calcium is not selected as a POC for any subcategory |
| Sodium | | ✓ | ✓ | Sodium is not selected as a POC for any subcategory |
| Yttrium | ✓ | ✓ | | |
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | ✓ | | | |
| Acenaphthylene | ✓ | | | |
| Acrylonitrile | ✓ | | | |
| Anthracene | ✓ | | | |
| Benzene | ✓ | ✓ | | |
| Benzidine | ✓ | | | |
| Benzo(a)anthracene | ✓ | | | |
| Benzo(b)fluoranthene | ✓ | | | |
| Benzo(k)fluoranthene | ✓ | | | |

Table 7-16 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| Benzo(ghi)perylene | ✓ | | | |
| Benzo(a)pyrene | ✓ | | | |
| Bis(2-chloroethoxy)methane | ✓ | | | |
| Bis(2-chloroethyl) Ether | ✓ | | | |
| Chloroform | ✓ | ✓ | ✓ | |
| 4-Chloro-3-methylphenol | ✓ | | | |
| Chrysene | ✓ | | | |
| Dibenzo(a,h)anthracene | ✓ | | | |
| Dibromochloromethane | ✓ | | | |
| 1,2-Dichloroethane | ✓ | | | |
| trans-1,3-Dichloropropene | ✓ | | | |
| 2,4-Dimethylphenol | ✓ | ✓ | | |
| 1,2-Diphenylhydrazine | ✓ | ✓ | | |
| Fluoranthene | ✓ | | | |
| Fluorene | ✓ | | | |
| Indeno(1,2,3-cd)pyrene | ✓ | | | |
| Methylene Chloride | ✓ | ✓ | | |
| Nitrobenzene | ✓ | | | |
| 2-Nitrophenol | ✓ | | | |
| 4-Nitrophenol | ✓ | | | |
| N-Nitrosodiphenylamine | ✓ | ✓ | | |
| Phenanthrene | ✓ | ✓ | | |
| Pyrene | ✓ | | | |
| Tribromomethane | ✓ | | | |
| Trichloroethene | ✓ | ✓ | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetophenone | ✓ | ✓ | | |
| 4-Aminobiphenyl | ✓ | | | |
| Aniline | ✓ | | | |
| Benzenethiol | ✓ | | | |

Table 7-16 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| 2,3-Benzofluorene | ✓ | | | |
| Benzyl Alcohol | ✓ | ✓ | | |
| Biphenyl | ✓ | ✓ | | |
| Carbon Disulfide | ✓ | ✓ | | |
| Carbazole | ✓ | | | |
| o-Cresol | ✓ | | | |
| p-Cresol | ✓ | | | |
| n-Decane | ✓ | ✓ | | |
| Dibenzofuran | ✓ | | | |
| Dibenzothiophene | ✓ | | | |
| 3,6-Dimethylphenanthrene | ✓ | | | |
| Dimethyl Sulfone | ✓ | | | |
| 1,4-Dioxane | ✓ | | | |
| Diphenylamine | ✓ | ✓ | | |
| n-Hexacosane | ✓ | ✓ | | |
| Methyl Ethyl Ketone | ✓ | ✓ | | |
| 4,5-Methylene Phenanthrene | ✓ | | | |
| 1-Methylfluorene | ✓ | | | |
| 1-Methylphenanthrene | ✓ | | | |
| alpha-Naphthylamine | ✓ | | | |
| beta-Naphthylamine | ✓ | | | |
| n-Octacosane | ✓ | | | |
| Perylene | ✓ | | | |
| 2-Phenylnaphthalene | ✓ | | | |
| 2-Picoline | ✓ | | | |
| Pyridine | ✓ | | | |
| Resorcinol | ✓ | | | |
| Styrene | ✓ | | | |
| Thianaphthene | ✓ | | | |
| o-Toluidine | ✓ | | | |

Table 7-16 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| n-Triacontane | ✓ | ✓ | | |
| 1,3,5-Trithiane | ✓ | | | |
| m- + p-Xylene | ✓ | | | |
| o-Xylene | ✓ | | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from at least one of the segments/operations within the subcategory. EPA did not incorporate segment/operational-level detail in this table because EPA sampled 14 different operations for this subcategory. See Section 5.4, DCN IS05030 of the iron and steel administrative record for detailed information presented by subcategory/segment/operation.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this subcategory.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-17

Pollutants of Concern
Steel Finishing Subcategory - Carbon and Alloy Steel Segment

| Pollutant Group | Pollutant of Concern | Acid Pickling | Cold Forming | Alkaline Cleaning | Hot Coating | Electroplating |
|---------------------------------------|---|----------------------|---------------------|--------------------------|--------------------|-----------------------|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Total suspended solids (TSS) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Chemical oxygen demand (COD) | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Fluoride | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Nitrate/nitrite | ✓ | | | ✓ | ✓ |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Total organic carbon (TOC) | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Total phenols | | ✓ | | | |
| | Sulfate | ✓ | | | | |
| Priority metals | Antimony | | | | ✓ | |
| | Arsenic | ✓ | ✓ | | ✓ | |
| | Chromium | ✓ | ✓ | | ✓ | ✓ |
| | Copper | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Lead | | | | ✓ | ✓ |
| | Nickel | ✓ | ✓ | | ✓ | ✓ |
| | Selenium | | | | | ✓ |
| | Zinc | ✓ | ✓ | ✓ | ✓ | ✓ |
| Nonconventional metals | Aluminum | | ✓ | | ✓ | |
| | Boron | | | | ✓ | |
| | Hexavalent chromium | | | | ✓ | ✓ |
| | Iron | ✓ | ✓ | ✓ | ✓ | ✓ |

Table 7-17 (Continued)

| Pollutant Group | Pollutant of Concern | Acid Pickling | Cold Forming | Alkaline Cleaning | Hot Coating | Electroplating |
|------------------------------------|-----------------------------|---------------|--------------|-------------------|-------------|----------------|
| Nonconventional metals (cont.) | Manganese | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Molybdenum | | | | ✓ | ✓ |
| | Tin | | | ✓ | | |
| | Titanium | ✓ | ✓ | | ✓ | ✓ |
| Priority organic pollutants | Bis(2-ethylhexyl) phthalate | | ✓ | | | |
| | 1,1,1-Trichloroethane | | ✓ | | | |
| Nonconventional organic pollutants | alpha-Terpineol | | ✓ | | | |
| | Benzoic acid | | ✓ | | | |
| | n-Dodecane | | ✓ | | | |
| | n-Eicosane | | ✓ | | | |
| | n-Hexadecane | | ✓ | | | |
| | n,n-Dimethylformamide | ✓ | | | | |
| | n-Octadecane | | ✓ | | | |
| | n-Tetradecane | | ✓ | | | |
| | 2-Propanone | ✓ | | | | |

(a) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Note: EPA did not identify POCs for stand-alone continuous annealing because EPA did not sample annealing quenching operations during its sampling program. POCs identified for the other finishing processes apply to continuous annealing.

Table 7-18

Pollutants of Concern
Steel Finishing Subcategory - Stainless Steel Segment

| Pollutant Group | Pollutant of Concern | Acid Pickling and Descaling | Cold Forming | Alkaline Cleaning |
|---------------------------------------|---|------------------------------------|---------------------|--------------------------|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) | ✓ | ✓ | ✓ |
| | Total suspended solids (TSS) | ✓ | ✓ | ✓ |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen | ✓ | ✓ | ✓ |
| | Chemical oxygen demand (COD) | ✓ | ✓ | ✓ |
| | Fluoride | ✓ | ✓ | ✓ |
| | Nitrate/nitrite | ✓ | | |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | ✓ | ✓ | ✓ |
| | Total cyanide | ✓ | | |
| | Total organic carbon (TOC) | ✓ | ✓ | |
| | Total phenols | | ✓ | |
| Priority metals | Antimony | ✓ | ✓ | |
| | Arsenic | ✓ | ✓ | |
| | Cadmium | ✓ | ✓ | |
| | Chromium | ✓ | ✓ | |
| | Copper | ✓ | ✓ | |
| | Lead | ✓ | | |
| | Nickel | ✓ | ✓ | |
| | Selenium | ✓ | | |
| | Zinc | ✓ | ✓ | |
| Nonconventional metals | Aluminum | ✓ | ✓ | |
| | Barium | ✓ | | |
| | Boron | ✓ | | |
| | Cobalt | ✓ | | |
| | Hexavalent chromium | ✓ | ✓ | |
| | Iron | ✓ | ✓ | ✓ |

Table 7-18 (Continued)

| Pollutant Group | Pollutant of Concern | Acid Pickling and Descaling | Cold Forming | Alkaline Cleaning |
|---------------------------------------|--------------------------------------|--|-------------------------|------------------------------|
| Nonconventional metals (cont.) | Magnesium | ✓ | | ✓ |
| | Manganese | ✓ | ✓ | ✓ |
| | Molybdenum | ✓ | ✓ | |
| | Tin | ✓ | ✓ | |
| | Titanium | ✓ | ✓ | ✓ |
| | Vanadium | ✓ | | |
| Priority organic pollutants | Ethylbenzene | | ✓ | |
| | Naphthalene | | ✓ | |
| | Phenol | | ✓ | |
| | Toluene | | ✓ | |
| Nonconventional organic pollutants | Benzoic acid | | ✓ | |
| | 2,6-Di-tert-butyl-p- benzoquinone | | ✓ | |
| | Hexanoic acid | | ✓ | |
| | 2-Methylnaphthalene | | ✓ | |
| | m-Xylene | | ✓ | |
| | n-Docosane | | ✓ | |
| | n-Dodecane | | ✓ | |
| | n-Eicosane | | ✓ | |
| | n-Hexadecane | | ✓ | |
| | n-Octadecane | | ✓ | |
| | n-Tetracosane | | ✓ | |
| | n-Tetradecane | | ✓ | |
| | o- + p-Xylene | | ✓ | |
| | 2-Propanone | | ✓ | |

(a) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Note: EPA did not identify POCs for stand-alone continuous annealing because EPA did not sample annealing quenching operations during its sampling program. POCs identified for the other finishing processes apply to continuous annealing.

Table 7-19

**Pollutants Not Identified as Pollutants of Concern
Other Operations Subcategory - Direct-Reduced Ironmaking Segment (a)**

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|--|---------------------------------|--|---|---|
| <i>Conventional Pollutants</i> | | | | |
| pH (SU) | | (e) | | pH is not selected as a POC for any subcategory |
| <i>Nonconventional Pollutants, Other (f)</i> | | | | |
| Chloride | | | | Except where noted, chloride is not selected as a POC for any subcategory |
| Nitrate/Nitrite (NO ₂ + NO ₃ -N) | ✓ | | | |
| Sulfate | | (e) | ✓ | Except where noted, sulfate is not selected as a POC for any subcategory |
| Total Dissolved Solids (TDS) | | (e) | | Except where noted, TDS is not selected as a POC for any subcategory |
| Total Kjeldahl Nitrogen (TKN) | | (e) | | |
| Total Organic Carbon (TOC) | | ✓ | | |
| Total Recoverable Phenolics | | ✓ | | |
| <i>Priority Metals</i> | | | | |
| Antimony | | ✓ | | |
| Arsenic | | ✓ | | |
| Beryllium | ✓ | | | |
| Cadmium | ✓ | | | |
| Chromium | | ✓ | | |
| Copper | ✓ | | | |
| Lead | | ✓ | | |
| Mercury | ✓ | | | |
| Nickel | ✓ | | | |
| Selenium | ✓ | | | |
| Silver | ✓ | | | |

Table 7-19 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|---|
| <i>Priority Metals (continued)</i> | | | | |
| Thallium | ✓ | | | |
| Zinc | | ✓ | ✓ | |
| <i>Nonconventional Metals</i> | | | | |
| Aluminum, Dissolved | | (e) | ✓ | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Antimony, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Arsenic, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Barium | | ✓ | | |
| Barium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Beryllium, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Boron | | ✓ | | |
| Boron, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Calcium | | | | Except where noted, calcium is not selected as a POC for any subcategory |
| Calcium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Chromium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Cobalt | ✓ | | | |
| Copper, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |

Table 7-19 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Iron, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Lead, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Magnesium | | ✓ | | |
| Magnesium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Manganese, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Mercury, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Molybdenum | | ✓ | | |
| Molybdenum, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Nickel, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Selenium, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Sodium | | | | Except where noted, sodium is not selected as a POC for any subcategory |
| Sodium, Dissolved | | (e) | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Tin | ✓ | | | |
| Titanium, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Vanadium | ✓ | | | |
| Yttrium | | ✓ | | |

Table 7-19 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|-----------------------------|--|---|---|
| <i>Nonconventional Metals (continued)</i> | | | | |
| Yttrium, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| Zinc, Dissolved | ✓ | | | Dissolved metals are not considered POCs because they are accounted for in the total metal analysis |
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | ✓ | | | |
| Acenaphthylene | ✓ | | | |
| Acrylonitrile | ✓ | | | |
| Anthracene | ✓ | | | |
| Benzene | ✓ | | | |
| Benzidine | ✓ | | | |
| Benzo(a)anthracene | ✓ | | | |
| Benzo(b)fluoranthene | ✓ | | | |
| Benzo(k)fluoranthene | ✓ | | | |
| Benzo(ghi)perylene | ✓ | | | |
| Benzo(a)pyrene | ✓ | | | |
| Bis(2-chloroethoxy)methane | ✓ | | | |
| Bis(2-chloroethyl) Ether | ✓ | | | |
| Bis(2-ethylhexyl) Phthalate | ✓ | | | |
| Chloroform | ✓ | | | |
| 4-Chloro-3-methylphenol | ✓ | | | |
| Chrysene | ✓ | | | |
| Dibenzo(a,h)anthracene | ✓ | | | |
| Dibromochloromethane | ✓ | | | |
| 1,2-Dichloroethane | ✓ | | | |
| trans-1,3-Dichloropropene | ✓ | | | |
| 2,4-Dimethylphenol | ✓ | | | |
| 1,2-Diphenylhydrazine | ✓ | | | |

Table 7-19 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Priority Organic Pollutants (continued)</i> | | | | |
| Ethylbenzene | ✓ | | | |
| Fluoranthene | ✓ | | | |
| Fluorene | ✓ | | | |
| Indeno(1,2,3-cd)pyrene | ✓ | | | |
| Methylene Chloride | ✓ | | | |
| Naphthalene | ✓ | | | |
| Nitrobenzene | ✓ | | | |
| 2-Nitrophenol | ✓ | | | |
| 4-Nitrophenol | ✓ | | | |
| N-Nitrosodiphenylamine | ✓ | | | |
| Phenanthrene | ✓ | | | |
| Phenol | | ✓ | | |
| Pyrene | ✓ | | | |
| Toluene | ✓ | | | |
| Tribromomethane | ✓ | | | |
| 1,1,1-Trichloroethane | ✓ | | | |
| Trichloroethene | ✓ | | | |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Acetone | ✓ | | | |
| Acetophenone | ✓ | | | |
| alpha-Terpineol | ✓ | | | |
| 4-Aminobiphenyl | ✓ | | | |
| Aniline | ✓ | | | |
| Benzenethiol | ✓ | | | |
| 2,3-Benzofluorene | ✓ | | | |
| Benzoic Acid | ✓ | | | |
| Benzyl Alcohol | ✓ | | | |
| Biphenyl | ✓ | | | |
| Carbazole | ✓ | | | |
| Carbon Disulfide | ✓ | | | |
| o-Cresol | ✓ | | | |

Table 7-19 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| p-Cresol | ✓ | | | |
| n-Decane | ✓ | | | |
| Dibenzofuran | ✓ | | | |
| Dibenzothiophene | ✓ | | | |
| 2,6-Di-tert-butyl-p-benzoquinone | ✓ | | | |
| N,N-Dimethylformamide | ✓ | | | |
| 3,6-Dimethylphenanthrene | ✓ | | | |
| Dimethyl Sulfone | ✓ | | | |
| 1,4-Dioxane | ✓ | | | |
| Diphenylamine | ✓ | | | |
| n-Docosane | ✓ | | | |
| n-Dodecane | ✓ | | | |
| n-Eicosane | ✓ | | | |
| n-Hexacosane | ✓ | | | |
| n-Hexadecane | ✓ | | | |
| Hexanoic Acid | ✓ | | | |
| Methyl Ethyl Ketone | ✓ | | | |
| 4,5-Methylene Phenanthrene | ✓ | | | |
| 1-Methylfluorene | ✓ | | | |
| 2-Methylnaphthalene | ✓ | | | |
| 1-Methylphenanthrene | ✓ | | | |
| alpha-Naphthylamine | ✓ | | | |
| beta-Naphthylamine | ✓ | | | |
| n-Octacosane | ✓ | | | |
| n-Octadecane | ✓ | | | |
| Perylene | ✓ | | | |
| 2-Phenylnaphthalene | ✓ | | | |
| 2-Picoline | ✓ | | | |
| Pyridine | ✓ | | | |

Table 7-19 (Continued)

| Pollutant | Not Detected (b) | Detected at Low Concentration (c) | Source Water Contaminant (d) | Comments |
|---|---------------------------------|--|---|-----------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| Resorcinol | ✓ | | | |
| Styrene | ✓ | | | |
| n-Tetracosane | ✓ | | | |
| n-Tetradecane | ✓ | | | |
| Thianaphthene | ✓ | | | |
| o-Toluidine | ✓ | | | |
| n-Triacontane | ✓ | | | |
| 1,3,5-Trithiane | ✓ | | | |
| m- + p-Xylene | ✓ | | | |
| o-Xylene | ✓ | | | |

(a) Pollutants were detected in at least one untreated wastewater sample during EPA's 18 iron and steel sampling episodes. Check marks in a column indicate that the criterium applies to data from this segment.

(b) Pollutant was not detected in untreated process wastewater samples from any operations in this segment.

(c) The pollutant was detected at greater than or equal to 10 times the minimum level concentration in less than 10 percent of all untreated process wastewater samples.

(d) The mean detected concentration in untreated process wastewater samples was less than or equal to the mean detected concentration in source water samples.

(e) Pollutant does not have a specified minimum level.

(f) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-20

Pollutants of Concern
Other Operations Subcategory - Direct-Reduced Ironmaking Segment

| Pollutant Group | Pollutant of Concern |
|---------------------------------------|---|
| Conventional pollutants | Oil and grease measured as hexane extractable material (HEM) |
| | Total suspended solids (TSS) |
| Nonconventional pollutants, other (a) | Ammonia as nitrogen |
| | Chemical oxygen demand (COD) |
| | Fluoride |
| | Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) |
| Nonconventional metals | Aluminum |
| | Iron |
| | Manganese |
| | Titanium |

(a) Nonconventional pollutants other than nonconventional metals.

Table 7-21

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Cokemaking Subcategory - By-Product Recovery Segment (a)**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Minimum Level |
|---|---------------------------------|---------------------------------|--|----------------------|
| <i>Conventional Pollutants</i> | | | | |
| Biochemical oxygen demand 5-day (BOD ₅) | 16 | 16 | Not Applicable | Not Applicable |
| Biochemical oxygen demand 5-day (BOD ₅) - carbonaceous | 16 | 15 | 94 | 2 |
| Oil and grease measured as hexane extractable material (HEM) | 16 | 16 | 69 | 5 |
| Total suspended solids (TSS) | 16 | 16 | 25 | 4 |
| <i>Nonconventional Pollutants, Other (b)</i> | | | | |
| Amenable cyanide | 16 | 13 | 81 | 0.02 |
| Ammonia as nitrogen | 16 | 16 | 100 | 0.01 |
| Chemical oxygen demand (COD) | 16 | 16 | 100 | 5 |
| Fluoride | 16 | 16 | 100 | 0.1 |
| Nitrate/nitrite | 16 | 15 | 75 | 0.05 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | 16 | 16 | Not Applicable | Not Applicable |
| Thiocyanate | 16 | 16 | Not Applicable | Not Applicable |
| Total Kjeldahl nitrogen (TKN) | 16 | 16 | Not Applicable | Not Applicable |
| Total organic carbon (TOC) | 16 | 15 | 94 | 1 |
| Total phenols | 16 | 16 | 100 | 0.05 |
| Weak acid dissociable (WAD) cyanide | 16 | 16 | Not Applicable | Not Applicable |
| <i>Priority Metals</i> | | | | |
| Arsenic | 16 | 15 | 25 | 0.01 |
| Mercury | 16 | 12 | 31 | 0.0002 |
| Selenium | 16 | 16 | 100 | 0.005 |
| <i>Nonconventional Metals</i> | | | | |
| Boron | 16 | 16 | 13 | 0.1 |

Table 7-21 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Minimum Level |
|--|---------------------------------|---------------------------------|--|----------------------|
| <i>Priority Organic Pollutants</i> | | | | |
| Acenaphthene | 16 | 12 | 63 | 0.01 |
| Acenaphthylene | 16 | 16 | 100 | 0.01 |
| Anthracene | 16 | 16 | 100 | 0.01 |
| Benzene | 16 | 16 | 100 | 0.01 |
| Benzidine | 9 | 1 | 11 | 0.05 |
| Benzo(a)anthracene | 16 | 11 | 63 | 0.01 |
| Benzo(a)pyrene | 15 | 10 | 60 | 0.01 |
| Benzo(b)fluoranthene | 15 | 10 | 53 | 0.01 |
| Benzo(k)fluoranthene | 15 | 7 | 33 | 0.01 |
| Benzo(ghi)perylene | 15 | 5 | 27 | 0.02 |
| Chrysene | 16 | 10 | 56 | 0.01 |
| 1,2-Dichloroethane | 16 | 2 | 13 | 0.01 |
| 2,4-Dimethylphenol | 16 | 16 | 100 | 0.01 |
| Ethylbenzene | 16 | 8 | 19 | 0.01 |
| Fluoranthene | 16 | 16 | 100 | 0.01 |
| Fluorene | 16 | 16 | 100 | 0.01 |
| Indeno(1,2,3-cd)pyrene | 16 | 5 | 25 | 0.02 |
| Naphthalene | 16 | 16 | 100 | 0.01 |
| Phenanthrene | 16 | 16 | 100 | 0.01 |
| Phenol | 16 | 16 | 100 | 0.01 |
| Pyrene | 16 | 16 | 100 | 0.01 |
| Toluene | 16 | 16 | 100 | 0.01 |
| <i>Nonconventional Organic Pollutants</i> | | | | |
| Aniline | 16 | 10 | 63 | 0.01 |
| 2,3-Benzofluorene | 16 | 3 | 13 | 0.01 |
| beta-Naphthylamine | 15 | 4 | 13 | 0.05 |
| Biphenyl | 16 | 9 | 56 | 0.01 |
| 2-Butanone | 16 | 5 | 13 | 0.05 |
| Carbazole | 16 | 16 | 100 | 0.02 |
| Carbon disulfide | 16 | 6 | 19 | 0.01 |
| Dibenzofuran | 16 | 16 | 100 | 0.01 |
| Dibenzothiophene | 16 | 10 | 56 | 0.01 |
| 4,5-Methylene phenanthrene | 16 | 9 | 44 | 0.02 |
| 2-Methylnaphthalene | 16 | 13 | 75 | 0.01 |

Table 7-21 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Minimum Level |
|--|---------------------------------|---------------------------------|--|----------------------|
| <i>Nonconventional Organic Pollutants (continued)</i> | | | | |
| 1-Methylphenanthrene | 16 | 4 | 19 | 0.01 |
| m- + p-Xylene | 15 | 15 | 100 | 0.01 |
| m-Xylene | 1 | 1 | 100 | 0.01 |
| 1-Naphthylamine | 16 | 10 | 63 | 0.01 |
| n-Eicosane | 16 | 5 | 25 | 0.01 |
| n-Hexadecane | 15 | 5 | 33 | 0.01 |
| n-Octadecane | 16 | 5 | 25 | 0.01 |
| o-Cresol | 16 | 16 | 100 | 0.01 |
| o- + p-Xylene | 1 | 1 | 100 | 0.01 |
| o-Toluidine | 16 | 5 | 31 | 0.01 |
| o-Xylene | 15 | 11 | 53 | 0.01 |
| p-Cresol | 16 | 16 | 100 | 0.01 |
| Perylene | 16 | 5 | 19 | 0.01 |
| 2-Phenylnaphthalene | 16 | 10 | 63 | 0.01 |
| 2-Picoline | 15 | 15 | 100 | 0.05 |
| 2-Propanone | 16 | 16 | 94 | 0.05 |
| Pyridine | 16 | 16 | 100 | 0.01 |
| Styrene | 15 | 15 | 100 | 0.01 |
| Thianaphthene | 16 | 14 | 88 | 0.01 |
| <i>Other Priority Pollutants</i> | | | | |
| Total cyanide | 16 | 16 | 100 | 0.02 |

(a) Mean, median, and detection limit range concentrations not disclosed to prevent compromising confidential business information.

(b) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

Table 7-22

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Ironmaking Subcategory**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|----------------|
| | | | | Mean | Median | | |
| Conventional Pollutants | | | | | | | |
| Oil and grease measured as hexane extractable material (HEM) | 30 | 12 | 0 | 13.2 | 13.1 | 5-6 | 5 |
| Total suspended solids (TSS) | 30 | 30 | 97 | 1320 | 586 | Not Applicable | 4 |
| Nonconventional Pollutants, Other (b) | | | | | | | |
| Amenable cyanide | 24 | 20 | 46 | 0.24 | 0.229 | 0.005 | 0.02 |
| Ammonia as nitrogen | 30 | 30 | 100 | 85.9 | 61.4 | Not Applicable | 0.01 |
| Chemical oxygen demand (COD) | 30 | 27 | 90 | 1370 | 356 | 10-20 | 5 |
| Fluoride | 30 | 30 | 100 | 31.9 | 18.6 | Not Applicable | 0.1 |
| Nitrate/nitrite | 30 | 29 | 90 | 4.29 | 3.6 | 1.6 | 0.05 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | 30 | 10 | Not Applicable | 11.5 | 12.8 | 5-6 | Not Applicable |
| Thiocyanate | 30 | 22 | 0 | 11.5 | 0.605 | 0.1 | Not Applicable |
| Total Kjeldahl nitrogen (TKN) | 26 | 26 | Not Applicable | 82.8 | 50.4 | Not Applicable | Not Applicable |
| Total organic carbon (TOC) | 30 | 25 | 67 | 19.6 | 21.2 | 10 | 1 |
| Total phenols | 30 | 21 | 3 | 0.206 | 0.135 | 0.05-0.1 | 0.05 |
| Weak acid dissociable (WAD) cyanide | 30 | 25 | Not Applicable | 0.184 | 0.0387 | 0.002 | Not Applicable |

Table 7-22 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|------------------------|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Priority Metals | | | | | | | |
| Arsenic | 30 | 27 | 17 | (a) | (a) | (a) | 0.01 |
| Cadmium | 30 | 24 | 23 | (a) | (a) | (a) | 0.005 |
| Chromium | 30 | 28 | 37 | (a) | (a) | (a) | 0.01 |
| Copper | 30 | 24 | 23 | (a) | (a) | (a) | 0.025 |
| Lead | 30 | 30 | 83 | (a) | (a) | Not Applicable | 0.05 |
| Mercury | 30 | 14 | 17 | (a) | (a) | (a) | 0.0002 |
| Nickel | 30 | 27 | 7 | (a) | (a) | (a) | 0.04 |
| Selenium | 30 | 19 | 33 | (a) | (a) | (a) | 0.005 |
| Silver | 30 | 11 | 7 | (a) | (a) | (a) | 0.01 |
| Thallium | 30 | 23 | 33 | (a) | (a) | (a) | 0.01 |
| Zinc | 30 | 30 | 100 | (a) | (a) | Not Applicable | 0.02 |
| Nonconventional Metals | | | | | | | |
| Aluminum | 30 | 30 | 90 | (a) | (a) | Not Applicable | 0.2 |
| Boron | 30 | 30 | 50 | (a) | (a) | Not Applicable | 0.1 |
| Iron | 30 | 30 | 100 | (a) | (a) | Not Applicable | 0.1 |
| Magnesium | 30 | 30 | 47 | (a) | (a) | Not Applicable | 5 |
| Manganese | 30 | 30 | 100 | (a) | (a) | Not Applicable | 0.015 |
| Molybdenum | 30 | 28 | 17 | (a) | (a) | (a) | 0.01 |
| Titanium | 30 | 29 | 77 | (a) | (a) | (a) | 0.005 |

Table 7-22 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|------------------------------------|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Priority Organic Pollutants | | | | | | | |
| Benzo(a)anthracene | 18 | 2 | 11 | 0.135 | 0.135 | 0.01 | 0.01 |
| Benzo(a)pyrene | 18 | 2 | 11 | 0.119 | 0.119 | 0.01 | 0.01 |
| Benzo(b)fluoranthene | 18 | 2 | 11 | 0.35 | 0.350 | 0.01 | 0.01 |
| Benzo(k)fluoranthene | 18 | 1 | 6 | 0.15 | 0.150 | 0.01-0.1 | 0.01 |
| Chrysene | 18 | 2 | 11 | 0.233 | 0.233 | 0.01 | 0.01 |
| 2,4-Dimethylphenol | 18 | 6 | 6 | 0.0608 | 0.0413 | 0.01-0.1 | 0.01 |
| Fluoranthene | 18 | 5 | 11 | 0.143 | 0.0152 | 0.01 | 0.01 |
| 4-Nitrophenol | 18 | 5 | 6 | 0.223 | 0.0860 | 0.05-0.5 | 0.05 |
| Phenanthrene | 18 | 6 | 11 | 0.0693 | 0.0172 | 0.01 | 0.01 |
| Phenol | 18 | 9 | 33 | 0.221 | 0.135 | 0.01 | 0.01 |
| Pyrene | 18 | 2 | 11 | 0.205 | 0.205 | 0.01 | 0.01 |
| Nonconventional Organic Pollutants | | | | | | | |
| n-Docosane | 18 | 1 | 6 | 0.115 | 0.115 | 0.01-0.1 | 0.01 |
| n-Eicosane | 18 | 2 | 11 | 0.162 | 0.162 | 0.01 | 0.01 |
| n-Hexadecane | 18 | 2 | 11 | 0.168 | 0.168 | 0.01 | 0.01 |
| n-Octadecane | 18 | 2 | 11 | 0.145 | 0.145 | 0.01 | 0.01 |
| n-Tetracosane | 18 | 1 | 6 | 0.2 | 0.2 | 0.01-0.1 | 0.01 |
| o-Cresol | 18 | 7 | 6 | 0.0691 | 0.026 | 0.01-0.1 | 0.01 |
| p-Cresol | 18 | 7 | 6 | 0.0905 | 0.0604 | 0.01-0.1 | 0.01 |
| Pyridine | 18 | 9 | 17 | 0.0965 | 0.072 | 0.01 | 0.01 |

Table 7-22 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|--|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Nonconventional Dioxin and Furans (concentrations in pg/L) | | | | | | | |
| 1,2,3,4,6,7,8-Heptachlorodibenzofuran | 12 | 5 | 17 | (a) | (a) | (a) | 50 |
| 1,2,3,4,7,8,9-Heptachlorodibenzofuran | 12 | 4 | 8 | (a) | (a) | (a) | 50 |
| 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 12 | 6 | 17 | (a) | (a) | (a) | 50 |
| 1,2,3,4,7,8-Hexachlorodibenzofuran | 12 | 4 | 17 | (a) | (a) | (a) | 50 |
| 1,2,3,6,7,8-Hexachlorodibenzofuran | 12 | 4 | 17 | (a) | (a) | (a) | 50 |
| 1,2,3,7,8,9-Hexachlorodibenzofuran | 12 | 2 | 8 | (a) | (a) | (a) | 50 |
| 2,3,4,6,7,8-Hexachlorodibenzofuran | 12 | 4 | 17 | (a) | (a) | (a) | 50 |
| 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | 12 | 2 | 8 | (a) | (a) | (a) | 50 |
| 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin | 12 | 3 | 8 | (a) | (a) | (a) | 50 |
| 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | 12 | 3 | 8 | (a) | (a) | (a) | 50 |
| Octachlorodibenzofuran | 12 | 5 | 8 | (a) | (a) | (a) | 100 |
| Octachlorodibenzo-p-dioxin | 12 | 10 | 17 | (a) | (a) | (a) | 100 |
| 1,2,3,7,8-Pentachlorodibenzofuran | 12 | 4 | 17 | (a) | (a) | (a) | 50 |
| 2,3,4,7,8-Pentachlorodibenzofuran | 12 | 4 | 17 | (a) | (a) | (a) | 50 |
| 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | 12 | 2 | 8 | (a) | (a) | (a) | 50 |
| 2,3,7,8-Tetrachlorodibenzofuran | 12 | 5 | 33 | (a) | (a) | (a) | 10 |
| Other Priority Pollutants | | | | | | | |
| Total Cyanide | 29 | 24 | 45 | 0.306 | 0.348 | 0.005 | 0.02 |

(a) Mean, median, and detection limit range concentrations not disclosed to prevent compromising confidential business information.

(b) Nonconventional pollutants other than nonconventional metals, nonconventional organic pollutants, and nonconventional dioxins and furans.

Table 7-23

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Integrated Steelmaking Subcategory**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|----------------|
| | | | | Mean | Median | | |
| Conventional Pollutants | | | | | | | |
| Oil and grease measured as hexane extractable material (HEM) | 42 | 15 | 0 | 12.6 | 11.25 | 5-6.25 | 5 |
| Total suspended solids (TSS) | 43 | 43 | 79 | 5040 | 958 | Not Applicable | 4 |
| Nonconventional Pollutants, Other (a) | | | | | | | |
| Ammonia as nitrogen | 42 | 33 | 79 | 0.665 | 0.5 | 0.1-1 | 0.01 |
| Chemical oxygen demand (COD) | 42 | 41 | 71 | 229 | 97 | 20 | 5 |
| Fluoride | 43 | 42 | 98 | 23.3 | 15.8 | 0.2 | 0.1 |
| Nitrate/nitrite | 42 | 41 | 69 | 1.99 | 1.98 | 0.01 | 0.05 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | 43 | 8 | Not Applicable | 11.2 | 8.38 | 5-6.25 | Not Applicable |
| Total organic carbon (TOC) | 42 | 12 | 19 | 136 | 26.2 | 10 | 1 |
| Priority Metals | | | | | | | |
| Antimony | 48 | 34 | 19 | 0.134 | 0.0855 | 0.002-0.03 | 0.02 |
| Beryllium | 48 | 3 | 6 | 0.0683 | 0.066 | 0.001 | 0.005 |
| Cadmium | 48 | 30 | 29 | 0.12 | 0.0368 | 0.001-0.005 | 0.005 |
| Chromium | 48 | 44 | 56 | 1.3 | 0.103 | 0.01 | 0.01 |
| Copper | 48 | 41 | 52 | 1.02 | 0.437 | 0.009-0.01 | 0.025 |
| Lead | 48 | 48 | 65 | 8.62 | 1.68 | Not Applicable | 0.05 |

Table 7-23 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|-----------------------------|--------------------------|--------------------------|---|--------------------------------|---------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Priority Metals (continued) | | | | | | | |
| Mercury | 48 | 26 | 6 | 0.00077 | 0.00056 | 0.0002 | 0.0002 |
| Nickel | 48 | 31 | 31 | 0.425 | 0.39 | 0.017-0.02 | 0.04 |
| Silver | 48 | 30 | 23 | 0.101 | 0.0597 | 0.005 | 0.01 |
| Zinc | 48 | 47 | 75 | 355 | 27.9 | 0.01 | 0.02 |
| Nonconventional Metals | | | | | | | |
| Aluminum | 48 | 48 | 60 | 4.77 | 3.17 | Not Applicable | 0.2 |
| Cobalt | 48 | 22 | 6 | 0.153 | 0.103 | 0.009-0.011 | 0.05 |
| Iron | 48 | 48 | 98 | 2490 | 237 | Not Applicable | 0.1 |
| Magnesium | 48 | 48 | 40 | 213 | 28 | Not Applicable | 5 |
| Manganese | 48 | 48 | 90 | 59.7 | 11.1 | Not Applicable | 0.015 |
| Molybdenum | 48 | 45 | 58 | 0.56 | 0.255 | 6.04 | 0.006 |
| Tin | 48 | 41 | 33 | 0.412 | 0.18 | 0.002-0.005 | 0.03 |
| Titanium | 48 | 45 | 33 | 0.412 | 0.193 | 0.004 | 0.005 |
| Vanadium | 48 | 27 | 33 | 0.732 | 0.627 | 0.009-0.01 | 0.05 |
| Priority Organic Pollutants | | | | | | | |
| Phenol | 23 | 13 | 17 | 0.0747 | 0.024 | 0.01-0.0227 | 0.01 |

(a) Nonconventional pollutants other than nonconventional metals.

Table 7-24

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Integrated and Stand-Alone Hot Forming Subcategory**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|----------------|
| | | | | Mean | Median | | |
| Conventional Pollutants | | | | | | | |
| Oil and grease measured as hexane extractable material (HEM) | 15 | 15 | 13 | 31.5 | 20.1 | Not Applicable | 5 |
| Total suspended solids (TSS) | 15 | 15 | 27 | 30.5 | 22 | Not Applicable | 4 |
| Nonconventional Pollutants, Other (a) | | | | | | | |
| Ammonia as nitrogen | 15 | 4 | 20 | 1.11 | 0.61 | 1 | 0.01 |
| Chemical oxygen demand (COD) | 15 | 15 | 73 | 72 | 63 | Not Applicable | 5 |
| Fluoride | 15 | 15 | 53 | 1.21 | 1.33 | Not Applicable | 0.1 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | 15 | 12 | Not Applicable | 29.2 | 21.9 | 5.36-5.52 | Not Applicable |
| Total organic carbon (TOC) | 15 | 11 | 7 | 5.62 | 6.46 | 10 | 1 |
| Priority Metals | | | | | | | |
| Antimony | 15 | 9 | 0 | 0.00866 | 0.0081 | 0.004-0.02 | 0.02 |
| Chromium | 15 | 10 | 7 | 0.0371 | 0.0188 | 0.002-0.0022 | 0.01 |
| Copper | 15 | 10 | 0 | 0.0172 | 0.015 | 0.0012-0.002 | 0.025 |
| Lead | 15 | 5 | 0 | 0.0114 | 0.006 | 0.015-0.028 | 0.05 |
| Nickel | 15 | 9 | 0 | 0.0964 | 0.0934 | 0.004-0.007 | 0.04 |
| Zinc | 15 | 6 | 27 | 0.384 | 0.508 | 0.0028-0.004 | 0.02 |

Table 7-24 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|------------------------|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Nonconventional Metals | | | | | | | |
| Iron | 15 | 15 | 80 | 14.1 | 6.42 | Not Applicable | 0.1 |
| Manganese | 15 | 15 | 20 | 0.0898 | 0.058 | Not Applicable | 0.015 |
| Molybdenum | 15 | 15 | 27 | 0.0646 | 0.034 | Not Applicable | 0.01 |
| Titanium | 15 | 1 | 0 | 0.0068 | 0.0068 | 0.0009-0.004 | 0.005 |

(a) Nonconventional pollutants other than nonconventional metals.

Table 7-25

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Non-Integrated Steelmaking and Hot Forming Subcategory**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|----------------|
| | | | | Mean | Median | | |
| Conventional Pollutants | | | | | | | |
| Oil and grease measured as hexane extractable material (HEM) | 20 | 12 | 10 | 27.3 | 17.4 | 5-6.75 | 5 |
| Total suspended solids (TSS) | 20 | 18 | 50 | 81.4 | 51 | 4 | 4 |
| Nonconventional Pollutants, Other (a) | | | | | | | |
| Ammonia as nitrogen | 20 | 9 | 45 | 0.255 | 0.21 | 0.06-1 | 0.01 |
| Chemical oxygen demand (COD) | 20 | 20 | 85 | 157 | 90 | Not Applicable | 5 |
| Fluoride | 20 | 20 | 80 | 56.8 | 11.5 | Not Applicable | 0.1 |
| Nitrate/nitrite | 20 | 16 | 40 | 2.6 | 0.49 | 0.01-0.05 | 0.05 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | 20 | 11 | Not Applicable | 18.8 | 10.3 | 5-6.75 | Not Applicable |
| Total organic carbon (TOC) | 20 | 20 | 70 | 37.8 | 26.1 | Not Applicable | 1 |
| Priority Metals | | | | | | | |
| Antimony | 20 | 14 | 20 | 0.0948 | 0.0188 | 0.002-0.02 | 0.02 |
| Chromium | 20 | 18 | 65 | 1.19 | 0.445 | 0.001 | 0.01 |
| Copper | 20 | 17 | 25 | 0.219 | 0.194 | 0.009-0.011 | 0.025 |
| Lead | 20 | 1 | 0 | 0.386 | 0.386 | 0.001-0.002 | 0.05 |
| Nickel | 20 | 18 | 70 | 1.62 | 0.783 | 0.028 | 0.04 |
| Zinc | 20 | 17 | 20 | 1.82 | 0.1 | 0.01 | 0.02 |

Table 7-25 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|-----------------------------|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Nonconventional Metals | | | | | | | |
| Aluminum | 20 | 19 | 10 | 0.66 | 0.413 | 0.037 | 0.2 |
| Boron | 20 | 20 | 25 | 0.944 | 0.455 | Not Applicable | 0.1 |
| Hexavalent Chromium | 14 | 8 | 36 | 0.181 | 0.15 | 0.01 | 0.01 |
| Iron | 20 | 20 | 100 | 32.9 | 7.69 | Not Applicable | 0.1 |
| Manganese | 20 | 20 | 80 | 0.548 | 0.450 | Not Applicable | 0.015 |
| Molybdenum | 20 | 20 | 85 | 4.33 | 4.05 | Not Applicable | 0.01 |
| Titanium | 20 | 12 | 10 | 0.0325 | 0.0123 | 0.003-0.005 | 0.005 |
| Priority Organic Pollutants | | | | | | | |
| Tribromomethane | 18 | 3 | 6 | 0.11 | 0.0939 | 0.01 | 0.01 |

(a) Nonconventional pollutants other than nonconventional metals.

Note: EPA did not identify POCs for vacuum degassing because EPA did not sample non-integrated vacuum degassing operations during its sampling program. POCs identified for continuous casting and hot forming apply to vacuum degassing.

Table 7-26

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Steel Finishing Subcategory**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|----------------|
| | | | | Mean | Median | | |
| Conventional Pollutants | | | | | | | |
| Oil and grease measured as hexane extractable material (HEM) | 112 | 72 | 32 | 4110 | 50.0 | 5-14.1 | 5 |
| Total suspended solids (TSS) | 110 | 97 | 63 | 2490 | 110 | 4 | 4 |
| Nonconventional Pollutants, Other (a) | | | | | | | |
| Ammonia as nitrogen | 110 | 76 | 69 | 15.6 | 1.31 | 0.1-1 | 0.01 |
| Chemical oxygen demand (COD) | 110 | 103 | 74 | 9890 | 213 | 5-20 | 5 |
| Fluoride | 110 | 108 | 55 | 185 | 1.5 | 0.3 | 0.1 |
| Nitrate/nitrite | 110 | 102 | 54 | 209 | 0.948 | 0.05-0.25 | 0.05 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) | 112 | 58 | Not Applicable | 1080 | 124 | 5-14.1 | Not Applicable |
| Sulfate | 109 | 103 | Not Applicable | 1110 | 84 | 2-10000 | Not Applicable |
| Total organic carbon (TOC) | 110 | 61 | 37 | 158 | 34 | 1-500 | 1 |
| Total phenols | 111 | 43 | 8 | 1.52 | 0.15 | 0.005-0.1 | 0.05 |
| Priority Metals | | | | | | | |
| Antimony | 112 | 65 | 5 | 0.077 | 0.0328 | 0.002-0.04 | 0.02 |
| Arsenic | 112 | 73 | 13 | 0.0489 | 0.0276 | 0.001-0.02 | 0.01 |
| Cadmium | 112 | 39 | 55 | 0.0849 | 0.0168 | 0.001-0.01 | 0.005 |
| Chromium | 112 | 104 | 63 | 221 | 0.359 | 0.009-0.01 | 0.01 |
| Copper | 112 | 98 | 49 | 1.99 | 0.430 | 0.008-0.1 | 0.025 |
| Lead | 112 | 88 | 12 | 2.38 | 0.0258 | 0.002 | 0.05 |

Table 7-26 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|-----------------------------|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Priority Metals (continued) | | | | | | | |
| Nickel | 112 | 94 | 42 | 10.6 | 0.371 | 0.016-0.018 | 0.04 |
| Selenium | 112 | 15 | 3 | 0.0351 | 0.022 | 0.002-0.02 | 0.005 |
| Zinc | 112 | 104 | 63 | 40.3 | 0.309 | 0.008-0.01 | 0.02 |
| Nonconventional Metals | | | | | | | |
| Aluminum | 112 | 84 | 23 | 3.57 | 0.459 | 0.031-0.065 | 0.2 |
| Barium | 112 | 112 | 1 | 0.113 | 0.0313 | Not Applicable | 0.2 |
| Boron | 112 | 41 | 24 | 13.8 | 2.16 | 0.027-0.054 | 0.1 |
| Cobalt | 112 | 56 | 11 | 0.246 | 0.0635 | 0.009-0.12 | 0.05 |
| Hexavalent chromium | 84 | 24 | 17 | 9.03 | 5.2 | 0.01-0.1 | 0.01 |
| Iron | 112 | 112 | 96 | 1270 | 107.5 | Not Applicable | 0.1 |
| Magnesium | 112 | 111 | 9 | 24.8 | 10.8 | 0.073 | 5 |
| Manganese | 112 | 111 | 71 | 11.7 | 1.07 | 0.001 | 0.015 |
| Molybdenum | 112 | 99 | 29 | 0.428 | 0.0476 | 0.002-0.003 | 0.01 |
| Tin | 112 | 89 | 8 | 0.29 | 0.0417 | 0.002-0.03 | 0.03 |
| Titanium | 112 | 86 | 39 | 2.81 | 0.0595 | 0.003-0.005 | 0.005 |
| Vanadium | 112 | 62 | 9 | 0.314 | 0.061 | 0.007-0.01 | 0.05 |
| Priority Organic Pollutants | | | | | | | |
| Bis(2-ethylhexyl)phthalate | 94 | 6 | 2 | 0.301 | 0.0577 | 0.01-10 | 0.01 |
| 1,1,1-Trichloroethane | 92 | 2 | 2 | 0.333 | 0.333 | 0.002-0.112 | 0.01 |
| Ethylbenzene | 92 | 5 | 5 | 0.565 | 0.298 | 0.002-0.01 | 0.01 |
| Naphthalene | 94 | 6 | 6 | 0.624 | 0.230 | 0.01-10 | 0.01 |

Table 7-26 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Priority Organic Pollutants (continued) | | | | | | | |
| Phenol | 94 | 4 | 2 | 0.161 | 0.120 | 0.01-10 | 0.01 |
| Toluene | 92 | 3 | 1 | 0.0587 | 0.0156 | 0.002-0.01 | 0.01 |
| Nonconventional Organic Pollutants | | | | | | | |
| alpha-Terpineol | 94 | 2 | 2 | 0.664 | 0.664 | 0.01-10 | 0.01 |
| Benzoic acid | 94 | 11 | 9 | 7.23 | 1.33 | 0.05-50 | 0.05 |
| 2,6-Di-tert-butyl-p-benzoquinone | 94 | 10 | 1 | 0.397 | 0.258 | 0.099-99 | 0.099 |
| Hexanoic acid | 94 | 13 | 6 | 0.171 | 0.0776 | 0.01-10 | 0.01 |
| 2-Methylnaphthalene | 94 | 5 | 1 | 0.0874 | 0.0692 | 0.01-10 | 0.01 |
| m-Xylene | 35 | 5 | 11 | 0.459 | 0.232 | 0.002-0.01 | 0.01 |
| n-Docosane | 94 | 8 | 4 | 0.305 | 0.246 | 0.01-10 | 0.01 |
| n-Dodecane | 94 | 14 | 5 | 1.69 | 0.051 | 0.01-1 | 0.01 |
| n-Eicosane | 94 | 15 | 13 | 1.34 | 0.133 | 0.01-1 | 0.01 |
| n-Hexadecane | 94 | 14 | 14 | 6.85 | 0.193 | 0.01-1 | 0.01 |
| N,N,-Dimethylformamide | 94 | 3 | 3 | 0.125 | 0.119 | 0.01-10 | 0.01 |
| n-Octadecane | 94 | 16 | 14 | 3.26 | 0.132 | 0.01-1 | 0.01 |
| n-Tetracosane | 94 | 9 | 6 | 0.155 | 0.181 | 0.01-10 | 0.01 |
| n-Tetradecane | 94 | 12 | 3 | 2.94 | 0.0368 | 0.01-1 | 0.01 |
| o- + p-Xylene | 35 | 5 | 11 | 0.245 | 0.129 | 0.002-0.01 | 0.01 |
| 2-Propanone | 92 | 27 | 11 | 1.02 | 0.369 | 0.00998-0.05 | 0.05 |

Table 7-26 (Continued)

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---------------------------|--------------------------|--------------------------|---|--------------------------------|---------------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Other Priority Pollutants | | | | | | | |
| Total cyanide (b) | Not available | Not available | Not available | Not available | Not available | Not available | Not available |

(a) Nonconventional pollutants other than nonconventional metals and nonconventional organic pollutants.

(b) EPA did not analyze for cyanide in finishing wastewaters; however, EPA selected cyanide as a POC for the finishing subcategory because it may be present in reducing salt bath descaling wastewaters.

Note: EPA did not identify POCs for stand-alone continuous annealing because EPA did not sample annealing quenching operations during its sampling program. POCs identified for the other finishing processes apply to continuous annealing.

Table 7-27

**Untreated Process Wastewater Characteristics for Pollutants of Concern
Other Operations Subcategory - Direct-Reduced Ironmaking Segment**

| Pollutant of Concern | Number of Times Analyzed | Number of Times Detected | Percentage of Samples Detected Greater Than 10x Minimum Level | Detected Concentrations (mg/L) | | Detection Limit Range for Nondetects | Minimum Level |
|---|--------------------------|--------------------------|---|--------------------------------|--------|--------------------------------------|---------------|
| | | | | Mean | Median | | |
| Conventional Pollutants | | | | | | | |
| Oil and grease measured as hexane extractable material (HEM) (a) | ND | ND | ND | ND | ND | ND | ND |
| Total suspended solids (TSS) | 1 | 1 | 100 | 450 | 450 | Not Applicable | 4 |
| Nonconventional Pollutants, Other (b) | | | | | | | |
| Ammonia as nitrogen | 1 | 1 | 0 | 13.9 | 13.9 | Not Applicable | 0.01 |
| Chemical oxygen demand (COD) | 1 | 1 | 100 | 68 | 68 | Not Applicable | 5 |
| Fluoride | 1 | 1 | 100 | 14.2 | 14.2 | Not Applicable | 0.1 |
| Total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) (a) | ND | ND | ND | ND | ND | ND | ND |
| Nonconventional Metals | | | | | | | |
| Aluminum | 1 | 1 | 100 | 8.18 | 8.18 | Not Applicable | 0.2 |
| Iron | 1 | 1 | 100 | 112 | 112 | Not Applicable | 0.1 |
| Manganese | 1 | 1 | 100 | 3.77 | 3.77 | Not Applicable | 0.015 |
| Titanium | 1 | 1 | 100 | 0.0839 | 0.0839 | Not Applicable | 0.005 |

(a) Oil and grease measured as hexane extractable material (HEM) and total petroleum hydrocarbons measured as silica gel treated-hexane extractable material (SGT-HEM) were not detected in DRI wastewaters; however, EPA considers HEM and SGT-HEM to be POCs for all iron and steel industry wastewaters.

(b) Nonconventional pollutants other than nonconventional metals.

ND - Not detected.

SECTION 8

POLLUTION PREVENTION AND WASTEWATER TREATMENT TECHNOLOGIES

This section describes the pollution prevention and wastewater treatment technologies that are used by the iron and steel industry to prevent the generation of wastewater pollutants or reduce the discharge of wastewater pollutants. EPA considered various combinations of these technologies as the basis for the effluent limitations and guidelines and standards evaluated for the final rule for the iron and steel industry. To evaluate these technologies, EPA developed a database of the following:

- In-process technologies and process modifications;
- Process water recycle technologies;
- Process wastewater discharge flow rates;
- End-of-pipe wastewater treatment technologies; and
- Treated process wastewater effluent quality.

EPA collected most data from industry surveys, analytical and production surveys, and the EPA wastewater sampling programs. The Agency also used other data sources, such as industry trade journals, online databases, and other publications. Section 3 describes these sources.

The processes used in manufacturing steel products use a significant amount of water, as described in Section 7. Common pollutants found in iron and steel wastewater include: scale; metal fines and dissolved metals; oil and grease; suspended solids; organic compounds such as benzo(a)pyrene, naphthalene, and total phenols; and inorganic pollutants such as ammonia, cyanide, and nitrates/nitrites. Consequently, the iron and steel industry uses wastewater minimization, pollution prevention, and wastewater treatment technologies to reduce both water use and pollutant discharge loadings for these pollutants of concern. These technologies achieve these reductions by retarding pollutant buildup and improving water quality to allow greater reuse; reducing the volume of wastewater treated and discharged; prolonging process bath life, enabling sites to spend less on process bath makeup and reduce bath treatment and disposal costs; and improving treated effluent quality by enhanced wastewater treatment.

Iron and steel facilities use a wide variety of technologies to treat wastewater generated on site and for pollution prevention. The technologies are grouped into the following four categories, as discussed in this section:

- Section 8.1 - Wastewater Minimization and Pollution Prevention Technologies;
- Section 8.2 - Process Modifications;
- Section 8.3 - Treatment Technologies; and
- Section 8.4 - Best Management Practices.

Table 8-1 summarizes the various technologies discussed in Sections 8.1 and 8.2, as well as the applicable subcategories for each technology. Table 8-2 summarizes the various wastewater treatment and sludge handling technologies discussed in Section 8.3, as well as the applicable subcategories for each technology.

8.1 Wastewater Minimization and Pollution Prevention Technologies

This section discusses the following various types of waste minimization and pollution prevention technologies:

- Section 8.1.1 - High-Rate Recycle;
- Section 8.1.2 - Countercurrent Cascade Rinsing;
- Section 8.1.3 - Acid Reuse, Recycle, and Recovery;
- Section 8.1.4 - Extension of Process Solution Life; and
- Section 8.1.5 - Evaporation with Condensate Recovery.

8.1.1 High-Rate Recycle

High-rate recycle systems consist of a water recirculation loop that recycles approximately 95 percent or more of the water from a process for reuse. High-rate recycle systems are commonly used in the iron and steel industry for product cooling and cleaning, as well as for air pollution control, in the following iron and steel operations: blast furnace ironmaking, sintering, basic oxygen furnace (BOF) steelmaking, vacuum degassing, continuous casting, and hot forming operations. Virtually all systems require a portion of the recirculated water to be continuously discharged (blowdown) to prevent contaminants from accumulating. This blowdown stream is then treated at an end-of-pipe treatment system or discharged to surface water or a publicly owned treatment works (POTW). Well-designed and operated high-rate recycle systems can significantly reduce the volume of wastewater discharged and the amount of fresh water added to the system as makeup by maximizing the recycle rate.

Various physical/chemical treatment technologies are used within high-rate recycle systems, such as solids removal devices, cooling devices, and water softening technologies, to improve water quality prior to reuse. Improved water quality allows recycle rates to significantly increase, which in turn allows blowdown rates and pollutant loadings discharged to significant decrease. Common pollutants in iron and steel wastewater from the operations listed above include: total suspended solids (TSS), oil and grease (O&G), ammonia, cyanide, organic compounds such as phenols, and metals; recycle loop treatment systems are designed to remove these pollutants. Recycle system treatment technologies commonly used for each process operation are listed below. Section 8.3 provides additional information regarding the design, operation, and performance of each treatment unit.

Specific treatment and water cooling units commonly included in high-rate recycle systems differ from operation to operation. Blast furnace ironmaking and sintering operations commonly use clarification to remove solids. Additionally, blast furnace ironmaking high-rate recycle systems also use cooling towers to control temperature prior to recycle. Wet-

open and wet-suppressed BOF steelmaking high-rate recycle systems use classifiers and clarifiers to remove solids, followed by cooling towers prior to recycle. These BOF systems can also use carbon dioxide injection to remove hardness from the wastewater, thus minimizing scale accumulation, which reduces blowdown requirements. Typical vacuum degassing high-rate recycle systems consist of clarifiers and cooling towers prior to recycle, with blowdown treated individually or with commingled blowdown from continuous caster and/or BOF steelmaking recycle systems. Typical continuous casting high-rate recycle systems include a primary scale pit followed by a clarifier for additional solids removal. The clarifier may be followed by a polishing filter. Most of the continuous casting wastewater is then cooled and recycled. Typical components of hot forming high-rate recycle systems are scale pits with oil skimming, clarification or filtration to remove additional O&G and solids, and cooling towers prior to recycle.

In summary, high-rate recycle systems allow approximately 95 percent or more of process wastewater to be recycled, which significantly reduces makeup water requirements and process wastewater discharge flow rates. Recycle loop water treatment enables sites to further increase recycle rates by improving recycle water quality and reducing blowdown requirements. Well-designed and operated high-rate recycle systems are an important component of EPA's technology options considered for the final rule, as discussed in Section 9, because they reduce both the volume of process wastewater discharged and the loading of pollutants of concern in iron and steel wastewater.

8.1.2 Countercurrent Cascade Rinsing

Countercurrent cascade rinsing refers to a series of consecutive rinse tanks that are plumbed to cause water to flow from one tank to another in the direction opposite of the product flow. Fresh water flows into the rinse tank located farthest from the process tank and overflows (i.e. cascades), in turn, to the rinse tanks closer to the process tank. This technique is called countercurrent rinsing because the product and the rinse water move in opposite directions. Over time, the first rinse becomes contaminated with drag-out solution and reaches a stable concentration that is lower than the process solution. The second rinse stabilizes at a lower concentration, which enables less rinse water to be used than if only one rinse tank were in place. The more countercurrent cascade rinse tanks (three-stage, four-stage, etc.), the less rinse water is needed to adequately remove the process solution. This differs from a single, once-through rinse tank where the rinse water is composed of fresh water that is discharged after use without any recycle or reuse.

The rinse flow rate needed to adequately dilute drag-out solution depends on the concentration of process chemicals in the initial process bath, the concentration of chemicals that can be tolerated in the final rinse tank to meet product specifications, the amount of drag-out carried into each rinse stage, and the number of countercurrent cascade rinse tanks. These factors are expressed in Equation 8-1 below:

$$V_r = \left(\frac{C_o}{C_f} \right)^{1/n} \times V_D \quad (8-1)$$

where:

| | | |
|-------|---|--|
| V_r | = | Flow through each rinse stage, gal/min; |
| C_o | = | Concentration of the contaminant(s) in the initial process bath, mg/L; |
| C_f | = | Tolerable concentration of the contaminant(s) in the final rinse to give acceptable product cleanliness, mg/L; |
| n | = | Number of rinse stages used; and |
| V_D | = | Drag-out carried into each rinse stage, expressed as a flow, gal/min. |

This mathematical rinsing model is based on complete rinsing (i.e., removal of all contaminants from the product) and complete mixing (i.e., homogeneous rinse water in each rinse stage). Under these conditions, each additional rinse stage can reduce rinse water use by 90 percent. These conditions are not achieved unless there is sufficient residence time and agitation to obtain complete mixing in the rinse tank. For less efficient rinse systems, each added rinse stage reduces rinse water use by 50 to 75 percent.

Countercurrent cascade rinsing systems have a higher capital cost than once-through rinsing systems and require more space due to the additional rinse tanks. Also, in countercurrent cascade rinsing, the relatively low flow rate through the rinse tanks may not provide the needed agitation for drag-out removal. In such cases, air or mechanical agitation may be required to increase rinsing efficiency.

Countercurrent cascade rinsing is used in steel finishing operations, including acid pickling, alkaline cleaning, electroplating, and hot dip coating. Unlike intermediate steel processing steps, such as continuous casting and hot forming, steel finishing operations require the steel to be relatively contaminant-free for processing. For this reason, high-rate recycle systems do not provide adequate water quality for steel finishing operations. For those steel finishing operations that can tolerate low levels of contaminants introduced by rinse water, countercurrent cascade rinsing provides effective rinsing while also minimizing fresh water requirements and wastewater discharge flow rates.

8.1.3 Acid Reuse, Recycle, and Recovery Systems

Acid reuse, recycle, and recovery systems are used extensively in the industry at sites that perform acid pickling. Virtually all sites use fume scrubbers to capture acid gases and prevent acid gas emissions. Many facilities also recover spent acid to reduce makeup acid requirements and to reduce spent acid treatment and/or disposal costs. Typical industrial acid

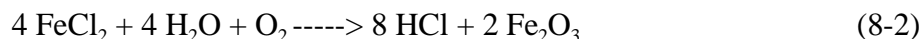
reuse and recovery systems include fume scrubbers, hydrochloric acid regeneration, sulfuric acid recovery, and acid purification. These technologies are described below.

Fume Scrubber Water Recycle

The steel finishing industry commonly uses fume scrubbers to capture acid gases from pickling tanks. Scrubber water, which may contain a dilute caustic solution, is neutralized and continuously recirculated to adsorb acid. Makeup water is added to replace water lost through evaporation and water that is blown down to end-of-pipe metals treatment. Blowdown is necessary to prevent salts buildup. Fume scrubber recirculation systems significantly reduce the volume of scrubber water discharged to wastewater treatment.

Hydrochloric Acid Regeneration

This process used in steel finishing operations consists of thermal decomposition of spent pickle liquor, which contains free hydrochloric acid, ferrous chloride, and water. The liquor is heated to remove some of the water through evaporation and to concentrate the solution. The concentrated solution is then further heated at 925°C to 1,050°C in a “roaster.” At this temperature, water is completely evaporated and the ferrous chloride decomposes into iron oxide (ferric oxide, Fe_2O_3) and hydrogen chloride (HCl) gas. Equation 8-2 below shows the decomposition process:



The iron oxide is separated and removed from the system for off-site recovery or disposal. The hydrogen chloride gas is reabsorbed in water (sometimes rinse water or scrubber water is used), to produce hydrochloric acid solution (generally from 15 to 21 percent HCl), which is reused in the pickling operation. There are several types of “roaster” processes in operation. The basic differences among the processes are the design and operation of the roaster/reactor and the recovery equipment (Reference 8-1).

Sulfuric Acid Recovery

To recover sulfuric acid in steel finishing operations, spent pickle liquor high in iron content is pumped into a crystallizer, where the iron is precipitated (under refrigeration or vacuum) as ferrous sulfate heptahydrate crystals. As the crystals are formed, water is removed with the crystals, and the free acid content of the solution increases to a level that is useable in the pickling operation. The crystals are separated from solution, and the recovered acid is pumped back into the pickling tank. The by-product ferrous sulfate heptahydrate is commercially marketable. The crystals are dried, bagged, and marketed, or sold in bulk quantities. Ferrous sulfate, commonly referred to as “copperas,” is used in appreciable quantities in numerous industries, including the manufacture of inks, dyes, paints, fertilizers, and magnetic tapes. It is also used as a coagulant in water and wastewater treatment (Reference 8-1).

Acid Purification and Recycle

Acid purification technology is used to process various acid pickling solutions, such as sulfuric acid and nitric/hydrofluoric acids used in stainless steel finishing mills. Acid is purified by adsorption on a bed of alkaline anion exchange resin that separates the acid from the metal ions. Acid is desorbed from the resin using water. The process begins by passing spent acid upward through the resin. A metal-rich, mildly acidic solution passes through the resin and is collected at the top of the bed. Water is then pumped downward through the bed and desorbs the acid from the resin. The purified acid solution is collected at the bottom of the bed. When the acid is effectively purified, it is withdrawn from the bed and recycled back to the process. Acid purification and recycle reduces nitrate discharges and the overall volume of acid pickling wastewater discharged because spent acid is not discharged to wastewater treatment. This technology can theoretically recover approximately 80 percent of the free acid remaining in a spent acid treatment solution; however, industrial experience with acid purification systems have not yielded the predicted recovery rate. EPA received comments on the proposed rule indicating that acid purification units reduce nitric acid consumption by as little as 12 percent.

8.1.4 Extension of Process Solution Life

Prolonging solution life reduces the investment in additional process solutions and time spent replacing spent process solutions. Iron and steel facilities use filtration, magnetic separation, and ion exchange technologies to extend process solution life. Filtration and magnetic separation technologies are described below while ion exchange is described in Section 8.3.1.

In-Tank Filtration

Steel finishing electroplating and alkaline cleaning operations use in-tank filters to extend process bath life by removing contaminants in the form of suspended solids. Recirculating cold forming operations also use filters to remove contaminants from the rolling solution. Paper, cloth, or plastic filters remove accumulated suspended solids or precipitant. Solids are usually disposed of off site. Devices such as granular activated carbon filters remove dissolved contaminants, such as organic constituents.

Magnetic Separation of Fines in Cold Rolling Solution

Magnetic separators are sometimes used in the iron and steel industry to extend the life of cold rolling solutions. Magnetic separators are installed in either rolling solution collection tanks or in a side-stream system connected to these tanks. The most effective systems use vertical or horizontal configurations of magnetic rods to remove metal fines. Well-designed magnetic separators can control the iron content in the rolling solutions to below 100 parts per million (Reference 8-2). Solids are usually shipped offsite for disposal.

8.1.5 Evaporation with Condensate Recovery

Evaporation is a wastewater minimization technology that steel finishing mills can use to recover electroplating chemicals such as chrome, nickel, and copper that are lost to electroplating rinse water. There are two basic types of evaporators: atmospheric and vacuum. Atmospheric evaporators, the more prevalent type, are relatively inexpensive to purchase and easy to operate. Vacuum evaporators are mechanically more sophisticated and are more energy-efficient. Vacuum evaporators are typically used when evaporation rates greater than 50 to 70 gallons per hour are required. Additionally, with vacuum evaporators, evaporated water can be recovered as a condensate and reused on site.

Electroplating rinse water is evaporated to concentrate drag-out metals. The resulting concentrated solution of these metals is then returned to the process bath. A disadvantage of evaporation-based recovery is that, in addition to drag-out, unwanted contaminants are returned to and accumulate in the electroplating process bath. For this reason, deionized water is preferred as rinse water to prevent introducing contaminants from the rinse water in the process bath. Another disadvantage of evaporation is that the process is energy-intensive, which may make evaporation cost prohibitive for some applications.

8.2 Process Modifications

Process modifications can reduce or eliminate wastewater generation at a facility. EPA identified three process modification technologies for use with acid pickling processes. Although the Agency is not aware of significant domestic use of these technologies, all are effectively used by foreign steel facilities. These technologies, effluent-free pickling with acid regeneration, nitric-acid-free pickling, and effluent-free exhaust cleaning, are described below. Table 8-1 summarizes the various technologies discussed in Section 8.2 as well as the applicable subcategories for each technology.

8.2.1 Effluent-Free Pickling Process with Fluid Bed Hydrochloric Acid Regeneration

This pickling process is operated such that no wastewater is discharged as spent pickle liquor, rinse wastewater, and scrubber water from a hydrochloric acid pickling line. The process is configured as a closed system that uses a fluidized bed reactor “roaster” configuration (hydrochloric acid regeneration is explained in detail above) to thermally decompose spent pickle liquor to hydrochloric acid and iron oxide (Reference 8-3). Figure 8-1 illustrates the fluidized bed acid regeneration system.

Spent pickle liquor is fed via a settling tank and venturi loop into the fluidized bed inside the reactor. The fluidized bed consists of granulated iron oxide. Residual acid and water are evaporated at 850°C and the iron chloride is converted to hydrochloric acid gas. Growth and new formation of iron oxide grains in the fluidized bed are controlled so that a dust-free granulated product is obtained. The iron oxide grains can be used as a raw material to

manufacture other products (e.g., as an additive for the production of magnetic tapes, abrasives, tiles, glass, cosmetics and pigments).

Since the fluidized bed process operates at approximately 850°C, rinse and scrubber water from the pickle line can be used at the regeneration plant to cool fluidized bed off-gases, which contain hydrochloric acid vapor and a small amount of iron oxide dust. The off-gases are cooled to approximately 100°C in a venturi scrubber. The thermal energy of the off-gases is used to concentrate the pickling liquor by evaporation before it is fed to the reactor. From the venturi scrubber, the cooled gas stream goes to the absorber, where hydrogen chloride is absorbed with rinse water from the pickling line and fresh water to produce hydrochloric acid. The acid can be recycled directly to the pickling process or placed in a storage tank for later use. Once the fluidized bed off-gases have passed through the scrubbing stages and mist collector, the off-gases are virtually free of hydrochloric acid and are released to the atmosphere.

8.2.2 Nitric-Acid-Free Pickling

Nitrate is a pollutant of concern for stainless steel acid pickling operations where nitric acids and combinations of nitric and hydrofluoric acids are used as surface treatments for various grades of stainless steels. Nitric-acid-free pickling requires the same equipment as conventional acid pickling processes, as well as agitating the bath to circulate fresh acid to the metal surface. The process is also compatible with acid regeneration. The Agency is aware of a proprietary commercial technology that uses a nitric-acid-free solution that contains an inorganic mineral acid base, hydrogen peroxide, stabilizing agents, wetting agents, brighteners, and inhibitors. See DCNs IS04072 and IS04075 in Section 5.5.1 of the Iron and Steel Rulemaking Record for more information.

8.2.3 Effluent-Free Exhaust Cleaning

Stainless steel pickling operations using mixed acid, nitric acid, or hydrofluoric acid produce exhaust gases that contain nitrogen oxide and hydrogen fluoride. Wet air pollution control (WAPC) devices are typically used to treat these exhaust gases, thereby generating wastewater. The Agency is aware of steel finishing mills that operate a commercially available technology that uses selective catalytic reduction (SCR) technology to treat exhaust gases from stainless steel pickling operations in lieu of WAPCs (Reference 8-4). The SCR system injects anhydrous ammonia into the gas stream prior to a catalyst to reduce NO_x to nitrogen and water. The most common types of catalysts are either a metal oxide, noble metal, or zeolite.

8.3 Treatment Technologies

This section discusses the following wastewater treatment technologies used at iron and steel facilities for recycle system water treatment prior to recycle and reuse, and/or end-of-pipe wastewater treatment prior to discharge to surface water or a POTW:

- Section 8.3.1 - Physical/Chemical Treatment;
- Section 8.3.2 - Biological Treatment; and
- Section 8.3.3 - Sludge Handling.

Table 8-2 summarizes the wastewater treatment and sludge handling technologies discussed in this section, as well as the applicable subcategories for each technology.

8.3.1 Physical/Chemical Treatment

The iron and steel industry extensively uses physical/chemical treatment technologies. Physical/chemical treatment can effectively remove iron and steel pollutants such as TSS, O&G, heavy organics (tars), ammonia, cyanide, and metals. Physical/chemical treatment is not effective in treating dissolved organic and inorganic compounds. The physical/chemical treatment technologies are described in the following order:

- Equalization;
- Tar Removal;
- Free and Fixed Ammonia Stripping;
- Cooling Technologies;
- Cyanide Treatment Technologies;
- Oily Wastewater Treatment Technologies;
- Carbon Dioxide Injection;
- Metals Treatment Technologies;
- Solids Separation Technologies; and
- Polishing Technologies.

Equalization

Equalization is a critical treatment component in achieving consistent wastewater treatment performance for end-of-pipe treatment systems. Equalization dampens fluctuations (reduces variability) in flow and influent wastewater quality. Equalization also eliminates shock loadings of inhibitory substances that would decrease treatment system efficiency and performance. Key design parameters for equalization are the required tank volume (i.e. wastewater residence time) and adequate mixing to enhance wastewater homogeneity. Two types of mixing are typically used in equalization systems: conventional top or side-mount impeller mixers and a pump system that continuously removes a portion of the wastewater from the tank and reintroduces it into the untreated wastewater flow.

Constant solids loading can improve the effluent quality and thickening performance of clarifiers. Equalization improves the performance of chemical precipitation systems as a result of improved chemical feed control and process reliability. Eliminating rapid flow increases to gravity clarification equipment lessens the chance of disrupting the sludge bed. For multimedia filtration systems, equalization results in a constant media filtration surface area requirement and more uniform filter-backwash cycles. Equalization prior to biological treatment dampens flow fluctuations to prevent a ‘wash out’ of the microorganisms. Equalization also

prevents shock loadings of compounds that are toxic to the microorganisms. Iron and steel facilities typically operate equalization systems to simultaneously achieve both flow and chemical equalization.

Tar Removal

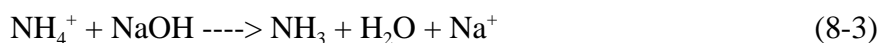
Tar decanters are used to recover oil and tar. The decanter is a rectangular steel tank, which is inclined at one end for solids removal. The tar and process liquor mixture enter the decanter and flow into a trough, which minimizes agitation of the mixture. The mixture then overflows to the main compartment where the velocity is reduced to allow the tar to separate from the process liquor and settle. The process liquor flows over a fixed weir to leave the decanter, while the tar is removed from the bottom of the decanter through an adjustable seal, the decanter valve. An optional mechanical filter can be placed on the tar decanter effluent to further separate residual tar and oil from the process liquor. The multiple tube filter uses a filter element made from porous aluminum oxide ceramic that can remove particulate as fine as 0.3 microns with flow rates of approximately 2 gallons per minute per square foot (gal/min/ft²). At the end of each filtration cycle, collected solids are removed from the filter by backwashing. Removing the large-chained organic compounds that comprise tar significantly reduces the carbonaceous biochemical oxygen demand (CBOD₅).

The iron and steel industry uses this treatment technology to treat the excess ammonia liquor generated during cokemaking operations. It separates tar and oil from the liquor, which is generally further treated in an ammonia stripping system.

Free and Fixed Ammonia Stripping

Free and fixed ammonia distillation, also referred to as stripping, involves transferring gas (ammonia) dissolved in a liquid (wastewater) into a gas stream (steam). When ammonia is present in both a free (NH₃) and fixed form (NH₄⁺), two stages or 'legs' are necessary for optimal removal efficiency. Figure 8-2 depicts an ammonia distillation column. The illustration shows both a free and fixed leg in one column. This configuration is common, but the industry also commonly uses two separate columns, one for each leg.

In the free leg, ammonia-rich liquor is pumped to the top of a tray-type distillation tower, also referred to as a still, and steam is injected into the base. As the rising steam passes through the boiling ammonia liquor moving down the tray tower, free ammonia is transferred from the liquid to the gas phase, eventually passing out the top of the tower. The hot, ammonia-rich steam is collected, cooled, and typically treated with sulfuric acid to form ammonium sulfate, a by-product that can be shipped off site for use as a fertilizer. Liquid collected from the bottom of the free leg is mixed either in a mix tank or inline with a basic solution, such as sodium hydroxide or soda ash, to raise the pH prior to the fixed leg. This step converts fixed ammonia to free ammonia as shown in the following equation:



The fixed leg then removes the converted ammonia in the same manner as the free leg. Liquid from the bottom of the fixed leg is cooled and transferred to a holding tank prior to further on-site treatment to remove any residual ammonia, or before discharge to a POTW.

Ammonia stripping also removes cyanide, phenols, and other volatile organic compounds (VOCs) typically found in cokemaking wastewater. Free cyanide, a component of total cyanide, is removed in the free leg, while VOCs, including phenols, are removed in both the free and fixed legs.

Based on data from EPA's iron and steel sampling program, well-operated ammonia distillation systems can remove approximately 99 percent of the ammonia from the waste stream. Additionally, the sampling data show typical removals of total cyanide and phenols of approximately 98 and 26 percent, respectively. The data also indicate other VOCs, found at low concentrations in the influent to the still, are removed to near or below the detection limit. The efficiency of the distillation tower is related to the number of trays (transfer units) that the liquid must pass over before reaching the bottom. Therefore, the higher the tower, the more trays and the greater the ammonia removal efficiency. The tower diameter is a function of the flow rate to the system. Spent ammonia liquor flows reported in industry surveys range from 30 to 360 gallons per minute (gpm). Ammonia distillation towers in the cokemaking industry typically range in height from 30 feet to over 100 feet, contain 20 to 30 trays, and have diameters ranging between 4 and 8 feet.

Cooling Technologies

Cooling technologies are used to attain water temperatures appropriate to facilitate end-of-pipe treatment and for reuse in high-rate recycle systems. Blast furnace, vacuum degassing, continuous casting, and hot forming operations use cooling methods in recirculation systems. By-product recovery cokemaking plants also commonly use cooling prior to biological treatment systems to prevent water temperatures detrimental to biomass.

- **Cooling Towers.** Cooling towers allow for temperature control for recycle process water. Counterflow induced draft cooling towers are common in the iron and steel industry. The counterflow arrangement is superior to the cross-flow tower for greater cooling ranges (Reference 8-5). Performance of a given cooling tower is governed by the ratio of the weights of air to water and the time of contact between water and air. The time of contact is governed largely by the time required for the water to discharge from the nozzles and fall through the tower to the basin. The time of contact is therefore obtained in a given type of unit by varying the height of the tower. Figure 8-3 illustrates a typical cooling tower. Cooling towers are also used in end-of-pipe treatment systems. Cooling towers used in ironmaking and steelmaking treatment systems cool 100-130°F water to approximately 75-85°F.

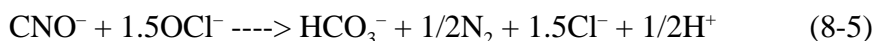
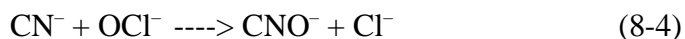
- **Shell-and-Tube Heat Exchangers.** This is an indirect contact device that facilitates the transfer of heat from one fluid stream to another. Counterflow, shell-and-tube heat exchangers are common in the iron and steel industry. Liquid to be cooled or heated is pumped through tubes that run the length of the heat exchanger's shell while another liquid to be cooled or heated is pumped through the shell and passes over the tubes. Baffles placed along the shell direct the flow in the shell over the tubes to promote turbulence and support tubes in horizontal units. Heat exchangers cool cokemaking wastewater from approximately 150-200° F to under 100°F prior to biological treatment.

Cyanide Treatment Technologies

Several treatment technologies are available and demonstrated to treat cyanide-containing wastewater and are used either as cyanide pretreatment or as a wastewater polishing step. In biological treatment, many microorganisms can acclimate to relatively high concentrations of cyanides and have been documented to successfully treat wastewater with cyanide concentrations up to 30 mg/L (Reference 8-6). However, in these cases, cyanide-containing wastewater is typically treated to remove cyanide as add-ons to biological treatment. Cyanide treatment technologies used by or applicable to the iron and steel industry are described below.

- **Alkaline and Breakpoint Chlorination.** Alkaline chlorination is used to destroy cyanide, and to a lesser extent, ammonia, and phenolics in wastewater. Alkaline chlorination uses sodium hypochlorite or chlorine gas in a carefully controlled pH environment to remove cyanide and ammonia; however, the system is operated to optimize cyanide removal at the expense of ammonia removal. The process oxidizes cyanide to bicarbonate and nitrogen gas, and ammonia to nitrogen gas, hydrochloric acid, and water, as illustrated by the following chemical reactions (Reference 8-6):

Cyanide:



Ammonia:



The equipment consists of two reaction tanks, each with an agitator and a pH and oxidation-reduction potential (ORP) controller. The first step (tank 1) of the reaction oxidizes cyanides to cyanate. To effect the

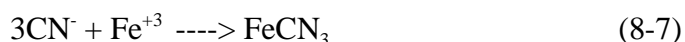
reaction, sodium hypochlorite or chlorine is metered into the reaction tank as necessary to maintain the ORP at 350 to 400 millivolts, and aqueous sodium hydroxide is added to maintain a pH of 10 to 11. This pH dictates that most of the cyanide exists in the CN^- form, rather than as the highly toxic hydrogen cyanide (HCN) form. In the second step (tank 2), the ORP and the pH level are maintained at 600 millivolts and 8 to 9, respectively, to oxidize cyanate to carbon dioxide and nitrogen. Each step has an agitator designed to provide approximately one turnover per minute.

Alkaline chlorination can be performed at ambient temperature, can be automatically controlled, and is capable of reducing effluent levels of cyanide to below detection. However, the reaction must occur at carefully controlled pH levels and has the possibility of chemical interferences when treating mixed wastes. Cyanide readily forms complexes with a number of metals, including zinc, iron, nickel, and cadmium, which are frequently found in iron and steel wastewater. These complexes reduce the effectiveness of alkaline chlorination treatment. Therefore, the effectiveness of the unit depends on the pretreatment and segregation of cyanide waste streams and the careful control of pH. The size and type of system solely depends on the cyanide waste stream flow volume (See Section 14.5 of the Iron and Steel Administrative Record for additional information regarding sizing of alkaline chlorination systems). In addition to wastewater segregation and careful pH control, another disadvantage of alkaline chlorination is that oxidation of organic compounds using chlorine has the potential to form trihalomethanes. Additionally, there are several safety concerns associated with the handling of chlorine gas and with the gas feed systems. This technology can be used to treat cyanide from by-product recovery cokemaking, blast furnace, and sintering operations.

Breakpoint chlorination is similar to alkaline chlorination in terms of equipment and controls, but distinctly different in terms of the operating pH (7 to 8) and the targeted pollutant (ammonia). Breakpoint chlorination is operated to optimize ammonia removal at the expense of cyanide removal, although incidental removals of cyanide and phenols will occur. Breakpoint chlorination uses the same treatment chemicals (chlorine or sodium hypochlorite) as alkaline chlorination, and the ammonia and cyanide chemical reactions are the same as those shown in Equations 8-4 through 8-6. Advantages of breakpoint chlorination are that treatment can be performed at ambient temperature, can be automatically controlled, and is capable of reducing effluent levels of ammonia to below detection. Disadvantages include an increase in dissolved solids of the wastewater and the potential for oxidation of organic compounds to form trihalomethanes, which are suspected carcinogens. Additionally, there are several safety concerns associated with the handling of chlorine gas and

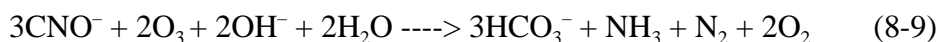
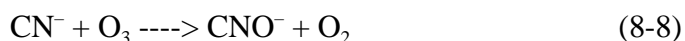
with the gas feed systems. Breakpoint chlorination can be used to treat both cokemaking and blast furnace ironmaking wastewater.

- **Cyanide Precipitation.** Cyanide precipitation combines cyanide in wastewater with iron to form an insoluble iron-cyanide complex that can be precipitated and removed by gravity settling. The process is illustrated by the following chemical reaction:



Excess iron is typically added as ferric sulfate ($\text{Fe}_2(\text{SO}_4)_3$) and the pH is adjusted to approximately 4.5 using sulfuric acid to optimize cyanide precipitation. Following complex formation, polymer is added to flocculate the iron-cyanide particulates, allowing them to settle in a gravity clarifier. Effluent from the gravity clarifier can be adjusted to a neutral pH prior to discharge, or the pH can be raised to approximately 9 to precipitate any residual metals. Industry survey data indicate that cyanide precipitation systems coupled with multimedia filtration can achieve effluent cyanide concentrations of approximately 1 mg/L. The iron and steel industry uses a proprietary cyanide precipitation technology to treat cokemaking wastewater.

- **Ozone Oxidation.** Cyanide removal can be accomplished through ozone oxidation. Ozone gas is bubbled through a wastewater solution containing cyanide. A portion of the ozone in the gas phase is transferred to the liquid where it reacts with cyanide, converting it to cyanate. Additional ozone reacts with the cyanate for complete conversion to nitrogen gas, ammonia, and bicarbonate as shown by the reactions below:



The reaction rate is limited by mass-transfer of ozone to the liquid, the cyanide concentration, and temperature (Reference 8-7). Ozone is not effective in treating metalocyanide complexes, such as ferrocyanide, unless ultraviolet light is added to the reaction vessel. Ozone also oxidizes other iron and steel pollutants of concern, such as ammonia and various organic compounds.

One advantage of ozone over chlorine is the type of residuals formed. Oxidation of organic compounds using chlorine has the potential to form trihalomethanes, which are suspected carcinogens. Ozone oxidation of organic compounds forms short chained organic acids, ketones, and aldehydes instead. Equipment required for ozone oxidation of cyanides

includes an ozone generator, gas diffusion system, a mixed reaction tank, and off-gas controls to prevent the release of unreacted ozone. The major disadvantages of ozone oxidation are the operating costs and the capital costs of the ozone generating and transfer equipment and off-gas control system. EPA is not aware of any iron and steel facilities using ozone treatment for cyanide.

Oily Wastewater Treatment Technologies

Hot forming and cold rolling operation wastewater contain high levels of O&G. For hot forming operations, scale pits and roughing clarifiers fitted with oil skimmers remove nonemulsified O&G from high-rate recycle systems. These technologies are discussed in the solids separation technologies subsection. Oily wastewater generated by cold rolling operations contain some emulsified oils that require chemical treatment prior to removal. Characteristics of emulsified oils vary widely, depending on the types of oils used in the process. The following describes technologies commonly used to remove both emulsified and nonemulsified oils.

- **Gravity Flotation.** Oil skimming via gravity flotation can be used for nonemulsified oil treatment. The wastewater is processed in a tank or basin of sufficient size and design to allow the oil to separate and rise to the surface. Typical wastewater residence times vary from 0.5 to over an hour. At the surface, the oil is retained by the underflow baffles and removed. Common devices used to separate nonemulsified oils include disk, belt, and rotating drum oil skimmers, and coalescers.

Skimming is a simple method to separate floating oil from wastewater. Skimming devices are typically mounted onto the side of a tank and operate on a continuous basis. The disk skimmer consists of a vertically rotating disk (typically 12 to 24 inches in diameter) that is partially submerged into the liquid of a tank (typically to a depth of 4 to 12 inches below the liquid surface). The disk continuously revolves between spring-loaded wiper blades that are located above the liquid surface. The adhesive characteristics of the floating oil cause the oil to adhere to the disk. The oil is removed from the disk as the disk surface passes through the wiper blades and is diverted to a run-off spout for collection. Maximum skimming rates typically range from 2 to 10 gallons per hour of oil. Belt and drum skimmers operate in a similar manner, with either a continuous belt or rotating drum partially submerged in a tank. As the surface of the belt or drum emerges from the liquid, the oil that adheres to its surface is scraped (drum) or squeezed (belt) off and diverted to a collection vessel.

Coalescers are typically designed as tanks containing a coalescing media that accelerates phase separation. The media in the coalescers is a material such as polypropylene, ceramic, or glass, which attracts oil in preference to

water (i.e., oleophilic). Oily wastewater passes through the unit and the oil adheres to the coalescing media. The oil forms droplets that conglomerate and rise to the surface of the tank where they are removed by a skimming device or weir (Reference 8-8). Gravity flotation is commonly used in the iron and steel industry to remove nonemulsified oils from hot forming and continuous casting wastewaters.

- ***Oil/Water Separation.*** The American Petroleum Institute (API) separator is the most commonly used type of oil/water separator to remove nonemulsified oils. The API oil/water separator is typically a rectangular basin, designed with baffles to trap sediments and retain floating oils, that can achieve 150-micron droplet oil removal as per API standards. This separator is used for wastewater containing nonemulsified oil with heavy solids content or when long retention times are required. Standard configurations of these systems include surface oil skimmers, sloped bottoms, and augers to remove collected sludge. Figure 8-4 presents an oil/water separator. Standard API oil/water separators can reduce solids concentrations to less than 100 mg/L. Oil/water separators are commonly used in the iron and steel industry to remove nonemulsified oils from hot forming, steel finishing, and forging wastewaters.
- ***Emulsion Breaking Followed by Dissolved Air Flotation.*** If wastewater contains emulsified oils, it must undergo chemical treatment to separate the oils from solution prior to further treatment steps. Chemical treatment breaks up stable oil/water emulsions (oil dispersed in water, stabilized by electrical charges and emulsifying agents). A stable emulsion will not separate without chemical treatment. Chemical emulsion breaking is used to treat wastewater streams containing emulsified coolants and lubricants. This technology is also used to treat cleaning solutions that contain emulsified oils.

The major equipment needed for chemical emulsion breaking includes reaction chambers with agitators, chemical storage tanks, chemical feed systems, pumps, and piping. Factors to be considered for breaking emulsions are type of chemicals, dosage and sequence of addition, pH, mixing, heating requirements, and retention time. Chemicals such as polymers, alum, ferric chloride, and organic emulsion breakers break emulsions by neutralizing repulsive charges between particles, precipitating or salting out emulsifying agents, or weakening the interfacial film between the oil and water so it is readily broken. Reactive cations (e.g., H^+ , Al^{+3} , Fe^{+3}) and cationic polymers are particularly effective in breaking dilute oil/water emulsions. Once the charges have been neutralized or the interfacial film broken, the small oil droplets and suspended solids either adsorb on the surface of the floc that is formed or break out and float to the top. Different types of emulsion-breaking

chemicals are used for different types of oils. If more than one chemical is necessary, the sequence of addition can affect both breaking efficiency and chemical dosages.

Wastes generated by chemical emulsion breaking include surface oil and oily sludge, which are usually contract hauled for disposal by a licensed contractor. If the recovered oil has a sufficiently low percentage of water, the oil may be burned for its fuel value or processed and reused.

Dissolved air flotation following chemical emulsion breaking is an effective method of oil removal. With dissolved air flotation, air is injected into a fluid under pressure. The amount of air that can dissolve in a fluid increases with increasing pressure. When the pressure is released, the air comes out of solution as bubbles that attach to O&G particles, thus “floating” the O&G to the surface. There are two types of operational modes for dissolved air flotation systems, full flow pressurization and recycle pressurization. In full flow pressurization, all influent wastewater is pressurized and injected with air. The wastewater then enters the flotation unit where the pressure is relieved and bubbles form, causing the O&G to rise to the surface. In a recycle pressurization system, part of the clarified effluent is recycled back to the influent of the dissolved air flotation unit, then pressurized and supersaturated with air. The recycled effluent then flows through a pressure release valve to the flotation unit. Figure 8-5 illustrates a typical dissolved air flotation unit.

Dissolved air flotation systems can achieve O&G removal efficiencies of 90% or greater. Emulsion breaking with dissolved air flotation requires more equipment, supervision, and control than gravity flotation and API separators; however, this technology is more efficient in removing O&G, especially nonemulsified oils. Emulsion breaking followed by dissolved air flotation is commonly used in the iron and steel industry to treat emulsified coolants, lubricants, and cleaning solutions.

- **Ultrafiltration.** Ultrafiltration is a pressure-driven membrane process that separates emulsified oils without the need for chemical emulsion breaking. Using an applied pressure difference across a membrane, wastewater and small compounds (oil and other contaminants) pass through the membrane and are collected as permeate while larger compounds (emulsified oils) are retained by the membrane and are recovered as concentrate.

Ultrafiltration is used in the iron and steel industry to remove materials ranging from 0.002 to 0.2 microns or molecular-weights from 500 to 1,000,000 (e.g., oil emulsion and colloidal silica) (Reference 8-9). Prefiltration of the ultrafiltration influent is commonly used to remove large particles and free oil to prevent membrane damage and membrane

fouling. Many ultrafiltration membranes are typically made of homogeneous polymer or copolymer material. The transmembrane pressure required for ultrafiltration typically ranges between 15 to 200 pounds per square inch and depends on membrane pore size.

Ultrafiltration generates a concentrated oil phase that is 2 to 5 percent of the influent volume (Reference 8-10). Oily concentrates are typically contract hauled or incinerated and the permeate (water phase) can either be treated further to remove water soluble metals and organic constituents or directly discharged, depending on local and state requirements.

The ultrafiltration system includes pumps and feed vessels, piping or tubing, monitoring and control units for temperature, pressure and flow rate, process and cleaning tanks, and membranes. Membranes are specifically designed to handle various waste stream parameters, including temperature, pH, and chemical compatibility. Membranes can be purchased in several different configurations, including hollow fiber, tubular, flat plate, and spiral wound (Reference 8-9). The configuration selected for each application depends on the type of application. For example, tubular membranes are commonly used to separate suspended solids, whereas spiral wound membranes are used to separate oil from water. The spiral wound design ultrafiltration membranes have a high membrane packing density and effective mass transfer characteristics.

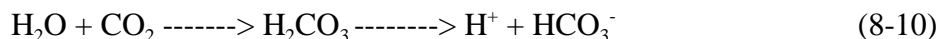
Ultrafiltration is more effective at removing emulsified oils than previously discussed technologies, and has a smaller design “foot print” than emulsion breaking/dissolved flotation systems. However, replacement membranes are expensive, and the technology requires more operator attention than gravity flotation and API separator systems. Ultrafiltration is commonly used in the iron and steel industry to treat emulsified coolants, lubricants, and cleaning solutions.

Carbon Dioxide Injection

Carbon dioxide injection is one method of removing scale-forming metal ions (hardness) that accumulate in water recirculation systems from BOF recycle water. Carbonate precipitation occurs in the recycle system through injection of carbon dioxide (CO₂) prior to clarification. Carbon dioxide is injected through a very fine bubble diffusion assembly, which is located in a basin with a minimum water depth of 10 feet. Liquid CO₂ can be stored on site and preheated prior to injection to create CO₂ gas. A series of baffles or a mixer directly above the CO₂ injection point help keep the bubbles submerged as long as possible.

Carbon dioxide can also be introduced by a pressurized solution feed system (PSF). The PSF system is designed to utilize 95 percent of the CO₂ feed gas. The gas is forced into a solution under high pressure to maintain the gas in solution until it is injected into the

wastewater. The carbonated solution, which is now carbonic acid and excess CO₂, is injected through a specially designed injector that maintains the PSF system pressure. This allows excess CO₂ gas, if any, to be released and immediately consumed by the wastewater. Both CO₂ delivery systems form carbonic acid and bicarbonate alkalinity as illustrated by Equation 8-10 below:



Carbonate reacts with magnesium and calcium ions to form insoluble precipitate, which is removed in a subsequent clarifier, as shown in Equation 8-11:



Carbon dioxide injection is commonly used by the iron and steel industry to reduce effluent hardness levels to 10 to 15 mg/L as CaCO₃ in BOF recycle systems. However, the layout of an existing recycle system may not allow installation of carbon dioxide storage for the injection system. Carbon dioxide injection systems require regular maintenance and testing of automatic controllers and calibration of electrodes to ensure system reliability.

Metals Treatment Technologies

Dissolved and total metals are present in high-rate recycle system blowdown wastewater from blast furnace, sintering, BOF, vacuum degassing, and continuous casting operations at levels that may require treatment before discharge. Pickling, electroplating, and other steel finishing processes also generate wastewater containing dissolved and total metals.

Chemical precipitation followed by gravity sedimentation is the treatment technology most commonly used by the industry to remove dissolved and total metals from wastewater. When chromium VI is present in the wastewater, hexavalent chromium reduction is commonly used as a pretreatment step prior to hydroxide precipitation for hexavalent-chromium-bearing wastewater generated by steel finishing operations. Below is a discussion of hexavalent chromium reduction and chemical precipitation.

- **Hexavalent Chromium Reduction.** Reduction is a chemical reaction in which electrons are transferred from one chemical (the reducing agent) to the chemical being reduced (the oxidizing agent). Sulfur dioxide, sodium bisulfite, sodium metabisulfite, and ferrous sulfate form strong reducing agents in water. Iron and steel finishing sites use them to reduce hexavalent chromium to the trivalent form, which allows the metal to be removed from solution by chemical precipitation. The reaction in these processes is illustrated by the following sulfur dioxide reaction (reduction using other reagents is chemically similar):



An operating pH level between 2 and 3 is typical. At pH levels above 5, the reduction rate is slow and oxidizing agents such as dissolved oxygen and ferric iron interfere with the reduction process by consuming the reducing agent. However, depending upon the initial pH, a significant amount acid may be required to lower and maintain the target pH.

Figure 8-6 presents a hexavalent chromium reduction system. Typical treatment involves retention in a reaction tank for 45 minutes. The reaction tank is equipped with pH and ORP controls. Sulfuric acid is added to maintain a pH of approximately 2.0, and a reducing agent is metered to the reaction tank to maintain the ORP at 250 to 300 millivolts. The reaction tank is equipped with an impeller designed to provide approximately one bath volume per minute.

Chemical reduction of hexavalent chromium is a proven technology widely used at iron and steel finishing sites to reduce hexavalent chromium concentrations prior to chemical precipitation. Operation at ambient conditions requires little energy, and the process is well suited to automatic control.

- **Chemical Precipitation.** Chemical precipitation involves removing metallic contaminants from aqueous solutions by converting soluble, heavy metals to insoluble salts. The precipitated solids are then removed from solution by flocculation followed by sedimentation and/or filtration. Precipitation is caused by the addition of chemical reagents that adjust the pH of the water to the minimum solubility of the metal. The standard reagents include the following:

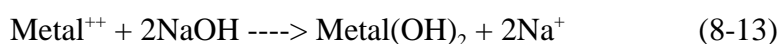
- Lime (calcium hydroxide),
- Caustic (sodium hydroxide),
- Magnesium hydroxide,
- Soda ash (sodium carbonate),
- Trisodium phosphate,
- Sodium sulfide, and
- Ferrous sulfide.

These reagents precipitate metals as hydroxides, carbonates, phosphates, and sulfides. The majority of iron and steel sites use lime or caustic for precipitation. Metals commonly removed from solution by precipitation include arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc.

Figure 8-7 shows a typical chemical precipitation process for metals removal. A chemical precipitant is added to the metal-containing water in a stirred reaction vessel. The dissolved metals are converted to an

insoluble form by a chemical reaction between the soluble metal and the precipitant. The suspended particles are then flocculated and either settled in a clarifier or removed via a membrane filter. Granular media filtration can be used for wastewater polishing to remove remaining suspended metal precipitates.

Hydroxide precipitation is the predominant type of chemical precipitation used by the iron and steel industry. Hydroxide precipitation normally involves using calcium hydroxide (lime), sodium hydroxide (caustic), or magnesium hydroxide as a precipitant to remove metals as insoluble metal hydroxides. The reaction is illustrated by the following equation for precipitation of a divalent metal using sodium hydroxide:



The effluent metals concentration attained by hydroxide precipitation depends on the metals present, precipitant used, the reaction conditions (especially pH), and the presence of other materials that may inhibit precipitation. Hydroxide precipitation achieves greater than 95% removal of metals found most frequently in industry wastewater, such as lead and zinc.

The solubility of the metal is directly related to the pH of its environment. Many metals can form low solubility hydroxides in the pH range of 8.5 to 11.5. However, several metallic compounds such as lead, zinc, nickel, and copper are amphoteric and exhibit a point of minimum solubility. Any further addition of alkali can drastically increase the solubility of the compound. Different metals have various minimum solubility points, which can pose a challenge when aqueous waste streams have highly variable metal compositions. Figure 8-8 shows the minimum solubilities of some common metals at various pH values (Reference 8-11). Figure 8-8 was developed based on empirical studies using single metal solutions in reagent-free water. Minimum metal solubilities in complex wastewater may differ from those shown in Figure 8-8.

The solubility curves in Figure 8-8 indicate that achieving the minimum solubility of all metals at a single operating pH would be difficult. At a pH at which the solubility of one metal hydroxide may be minimized, the solubility of another may be relatively high. In most cases, a pH between 9 and 11, selected on the basis of jar tests or operating experience with the water, produces an acceptable effluent quality. For a waste containing several metals, however, more than one precipitation/sedimentation stage with different pH control points may be necessary to remove all the metals of concern to the desired level. In practice, however, iron and steel

facilities generally use only one-stage precipitation optimized for greatest removal of targeted metals.

Incidental iron coprecipitation also occurs at facilities discharging spent hydrochloric and/or sulfuric acid to treatment. Pollutants of concern (metals) are enmeshed by the iron precipitates, and subsequently removed during a solids removal step. Some facilities add ferric chloride or ferric sulfate to induce coprecipitation.

Removal of precipitated metals typically involves adding flocculating agents or polymers to destabilize the hydrodynamic forces that hold the particle in suspension. For a continuous system, polymer is normally added in-line between the reaction tank and the flocculation tank. In the flocculation tank, the mixer is slowed to promote agglomeration of the particles until their density is greater than water and they settle from solution in the clarifier.

- ***Ion Exchange.*** Ion exchange is a reversible chemical reaction that exchanges ions (typically metals) in a feed stream for ions of like charge on the surface of an ion-exchange resin. Resins are broadly divided into cationic or anionic types. Typical cation resins exchange H^+ for other cations, while anion resins exchange OH^- for other anions. Figure 8-9 shows a typical ion exchange system. Many types of process wastewater are excellent candidates for ion exchange, including the rinse water from plating processes of lead, nickel, tin, tin-lead, chromium, and zinc.

Ion exchange can be used for steel finishing water recycling and/or metal recovery. For water recycling, cation and anion columns are placed in series. The feed stream is deionized and the product water is reused for rinsing. The regenerant from the cation column typically contains metal species (with the exception of chromium, which is captured in the anion column), which can be recovered in elemental form. The anion regenerant, which does not contain metals, is typically discharged to end-of-pipe wastewater treatment. When metal recovery is the only objective, a single or double cation column unit containing selective resin is used. These resins attract divalent cations while allowing monovalent cations to pass, a process usually referred to as metal scavenging. Water cannot be recycled because contaminants other than the target cations remain in the stream exiting the column.

Ion exchange equipment ranges from small, manual, single-column units to multicolumn, highly automated units. For continuous service, two sets of columns are necessary. One set handles the service flow, while the other set is regenerated. Thus, two-column metal scavenging and four-column deionizing systems are common. Automatic systems direct the

wastewater flow and initiate regeneration with little or no operator interaction. Equipment size is based on flow volume and concentration. Resin capacity varies but often ranges from 1 to 2 pounds per cubic feet. Columns are typically sized to handle wastewater flow for at least a period of time equal to the time required for regeneration. Automatic systems are sized to provide continuous service. Regeneration volume typically ranges from 2 to 4 resin bed volumes of a dilute acid or caustic.

Other similar technologies that could be applied to pickling and electroplating wastewater generated by steel finishing operations include electrowinning and reverse osmosis. Electrowinning can recover metals from ion exchange regenerants and return the metals to the plating bath. Reverse osmosis is a membrane technology that can be used to recover metal salts and generate a treated water stream that can be recycled for use as a rinse water. Neither of these technologies were reported in industry survey responses as a metals recovery technology; however, these technologies are commonly used in similar electroplating operations and are therefore applicable to the iron and steel finishing industry. For more information on these processes, refer to the Development Document for the Proposed Effluent Limitations Guidelines and Standards for the Metal Products and Machinery Point Source Category (Reference 8-10).

Solids Separation Technologies

Iron and steel facilities generate many types of solid wastes, including scale, biosolids, precipitate from cyanide and chemical precipitation systems, and solids from filtration backwash. The most common types of solids separation technologies used are scale pits, classifiers, and clarifiers.

- ***Scale Pits with Oil Skimming.*** Scale pits provide primary sedimentation and oil separation for recycle process water. Scale pits remove large, easily settleable iron scale. Pits are scraped or dredged to remove iron scale for reuse or disposal in a landfill on or off site. Oil is typically skimmed from the surface of the wastewater by a rope or belt skimmer and collected for off-site reclamation.
- ***Classifiers.*** Classifiers provide additional primary sedimentation for recycle process water. Solids are removed using screw or rake systems and typically disposed of on or off site.
- ***Clarification/Sedimentation.*** Gravity sedimentation in clarifiers is a common method of solids removal used in recycle and end-of-pipe treatment systems. Figure 8-10 depicts a typical clarifier. To improve the performance of high-efficiency and roughing clarifiers, coagulants such as polymers are added. These coagulant aids enhance solids removal by

aiding in the formation of larger, more readily settleable particles. High-efficiency clarifiers are used for end-of-pipe treatment and within water recycle systems that do not need water quality that is equivalent to filtered effluent for reuse in manufacturing processes. Systems with large amounts of scale or suspended solids need to pump contact cooling waters that collect in scale pits to a roughing clarifier for coarse solids removal prior to filtration, cooling, and recirculation.

Two important design parameters for roughing and high-efficiency clarifiers include the surface area of the clarifier and the detention time. Both high-efficiency and roughing clarifiers are normally designed on the basis of a surface-loading rate expressed as gallons per day per square foot of surface area (gal/day/ft²) and provide 90 to 150 minutes of detention based on the average flow rate (Reference 8-5). The surface-loading rate depends on the type of material to be separated. The table below shows the range of surface loading rates for high-efficiency clarifiers (Reference 8-12).

| Suspension | Range gal/day/ft ² | Peak Flow gal/day/ft ² |
|-------------------------|-------------------------------|-----------------------------------|
| Activated sludge solids | 590 - 785 | 1,460 |
| Alum floc | 613 - 1,200 | 1,200 |
| Iron floc | 613 - 1,200 | 1,200 |
| Lime floc | 730 - 1,460 | 1,460 |
| Untreated wastewater | 613-1,200 | 1,200 |

However, unlike more efficient clarifiers, roughing clarifiers are designed to remove large solids that rapidly settle. Therefore, surface loading rates may be three to four times those observed for high-efficiency clarifiers presented in the table. When the area of the tank has been established, the detention period in the tank is governed by the water depth.

Open-top circular or rectangular shaped clarifiers are typically used for sedimentation of biological treatment solids (also referred to as secondary clarification). For sedimentation of iron-cyanide solids, inclined tube or lamella clarifiers are commonly used. Depending on land availability and wastewater flow rates, open-top, inclined tube, or lamella clarifiers are used for sedimentation of metal hydroxides generated from treatment of ironmaking, steelmaking, and steel finishing wastewater. The inclined tubes in the clarifier are oriented at angles varying between 45 and 60 degrees from the horizontal plane. Although the tube may be shaped in many forms, rectangular or square shapes are more common. Water enters the tank and solids settle to the tank bottom. As the water continues

upward through the tubes, additional solids settle on the lower side of the tube. The clarified effluent continues up through the tube and passes over the weir. The solids collect and agglomerate on the lower side of the tube and, because of the tube inclination, slide downward through the tube.

They then drop back into the settling tank, where they collect on the bottom, and are scraped away into a sludge hopper before discharge to a sludge thickener. The surface area or “foot print” covered by the lamella plates is typically 65 to 80 percent of that required for a circular clarifier. Their design promotes laminar flow within the tubes, which enhances solids settling, even when the water throughput is relatively high. However, short circuiting or flow surges can reduce clarifier effectiveness. Lamella clarifiers are commonly used in the iron and steel industry to clarify steel finishing wastewater. Ironmaking and steelmaking wastewater treatments systems have substantially higher flows than finishing systems, and therefore use common circular clarifiers.

- ***Microfiltration for Precipitated Metals Removal.*** One alternative to conventional clarifiers for removal of insoluble solids, following chemical precipitation systems, is microfiltration. Microfiltration has been observed at facilities manufacturing metal products and machinery and could potentially be used to remove solids from chemical precipitation effluents at iron and steel facilities (Reference 8-10). Microfiltration is a pressure-driven membrane process used to separate solution components based on molecular size and shape. Using an applied pressure difference across a membrane, solvent (wastewater) and small solute (pollutants) species pass through the membrane and are collected as permeate while larger compounds are retained by the membrane and are recovered as concentrate.

Microfiltration is used to remove materials ranging from 0.1 to 1.0-microns (e.g., colloidal particles, heavy metal particulates and their hydroxides). Numerous microfiltration membranes are isotropic in morphology and are typically made of homogeneous polymer material. Prefiltration is advisable for suspended solids loads above 200 mg/l. The transmembrane pressure required for microfiltration typically ranges between 3 to 50 pounds per square inch (psi) and depends on membrane pore size.

Microfiltration generates a concentrated suspended solid slurry that is typically discharged to dewatering equipment, such as a sludge thickener and filter press. The permeate can either be treated further for pH adjustment or be directly discharged, depending on local and state requirements. The microfiltration system includes pumps and feed vessels, piping or tubing, monitoring and control units for temperature, pressure and flow rate, process and cleaning tanks, and membranes.

Membranes are specifically designed to handle various waste stream parameters, including temperature, pH, and chemical compatibility. Membranes can be purchased in several different configurations, including hollow fiber, tubular, flat plate, and spiral wound (Reference 8-9). The configuration selected for each application depends on the type of application. For example, tubular membranes are commonly used to separate suspended solids, whereas spiral wound membranes are used to separate oils from water. The tubular design microfiltration membranes are the least likely to foul with heavy suspended solids loadings and are easy to clean. Microfiltration is more effective at solids removal and has a smaller design “foot print” than conventional clarifiers. However, replacement membranes are expensive, and the technology requires more operator attention than a clarifier.

Polishing Technologies

Polishing technologies are the final treatment steps designed to remove residual, low concentrations of target pollutants from iron and steel wastewater prior to discharge. Examples of polishing technologies include multimedia filters following clarification to remove small concentrations (less than 20 mg/L) of entrained suspended solids, or carbon adsorption to remove trace concentrations of organic pollutants remaining in cokemaking wastewater following biological treatment. The following paragraphs describe each of these polishing technologies observed at iron and steel facilities.

- ***Multimedia Filtration (Mixed-Media Filtration).*** Multimedia filtration, one of the oldest and most widely applied types of filtration used to remove suspended solids from wastewaters, uses a bed of granular particles as the filter medium. Figure 8-11 illustrates a multimedia filter. The bed may consist of one type of medium (e.g., sand) of varying particle size or different types of media (e.g., sand and gravel, sand and anthracite) with differing densities and different particle sizes (Reference 8-12).

Multimedia filters can be more efficient but more expensive and complex than single-media filters. The filter bed is contained within a basin or tank and is supported by an underdrain system, which allows the filtered liquid to be drawn off while retaining the filter medium in place. As suspended particle-laden water passes through the bed of the filter medium, particles are trapped on top of and within the bed. When the pressure drop across the filter is large enough to impede flow, it is cleaned to remove solids by backwashing, whereby wash water is forced through the bed in the reverse direction of original fluid flow. Backwashing causes the bed to become fluidized, with solids being entrained and discharged with wash water. The backwash water is typically sent to clarifiers or gravity thickeners to remove the solids. For dual media filters, the filtration rate varies from 2 to 8 gpm/ft² with bed depths ranging from 24 to 48 inches.

While multimedia filtration is a proven technology for fine particle removal, the system requires proper attention to monitoring, maintenance, and backwash cycles to maximize filter efficiency. Bed shrinkage is a potential problem for filters. When the media grains (typically sand) become covered by a slime coating, this causes the bed to compact and possibly to develop cracks. These cracks may allow unfiltered wastewater to pass through the bed. Also, air binding, caused by a release of nitrogen and/or oxygen gases dissolved in the wastewater, creates air bubbles in the bed, which may interfere with the filtration rate.

Granular media filters are used to remove suspended solids from cokemaking wastewater following biological treatment, and from high-rate recycle cooling water and blowdown water from blast furnace ironmaking, sintering, continuous casting, and hot forming operations.

- ***Granular Activated Carbon.*** Granular activated carbon (GAC) removes dissolved organic compounds from wastewater streams via adsorption. Adsorption is a natural process by which molecules of a dissolved compound collect on and adhere to the surface of an adsorbent solid. Adsorption occurs when the attractive forces at the carbon surface overcome the attractive forces of the liquid. Activated carbon is a well-suited medium for this process due to its large internal surface area, high attraction to adsorbates (pollutants to be removed), and hydrophobic nature (i.e., water will not occupy bonding sites and interfere with the adsorption of pollutants). Pollutants in the wastewater bond to the activated carbon grains until all the surface bonding sites are occupied. When all bonding sites are occupied, the carbon is considered to be “spent.” Spent carbon requires regeneration, which reduces adsorption capacity. After several regenerations, the carbon is disposed.

A granular carbon system generally consists of vessels in which the carbon is placed, forming a “filter” bed. Vessels are usually circular for pressure systems or rectangular for gravity flow systems. For wastewater treatment, activated carbon is packed into one or more filter beds or columns. Typical treatment systems consist of multiple filter beds in series. Wastewater flows through the filter beds and is allowed to come in contact with all portions of the activated carbon. The activated carbon in the upper portion of the column is spent first (assuming operation is downflow mode), and progressively lower regions of the column are spent as the adsorption zone moves down the unit. When pollutant concentrations at the bottom of the column begin to increase above acceptable levels, the entire column is considered spent and must be replaced.

All vessels are equipped with carbon removal and loading mechanisms to allow spent carbon to be removed and new material to be added. Vessels

are backwashed periodically to remove the accumulated suspended solids in the filter bed. Surface wash and air scour systems can also be used as part of backwash cycle. Activated carbon systems may include on-site carbon storage vessels and thermal regeneration facilities, or off-site vendors may provide these services.

Activated carbon effectively removes a wide range of soluble organic compounds, and can produce a high-quality effluent. However, activated carbon beds must be backwashed periodically to avoid a buildup of head loss from solids accumulation. This backwash must then be treated prior to discharge. Additionally, the bed must be regenerated once the carbon is spent. If the regeneration is not performed on site, the spent carbon is sent to off-site vendors. Activated carbon adsorption is used as a polishing treatment step to remove residual concentrations of phenol and polyaromatic hydrocarbons (PAHs) from cokemaking wastewater following biological treatment.

8.3.2 Biological Treatment

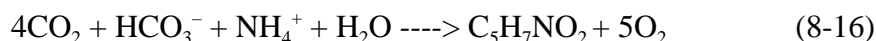
Biological treatment uses bio-oxidation to remove organic materials from wastewater. Microorganisms under aerobic conditions use the organic materials as substrates, thus removing them by microbial respiration and synthesis (Reference 8-13). Biological treatment with nitrification also incorporates ammonia removal via conversion to nitrate by biological processes. Biological denitrification then converts the nitrate to nitrogen gas. Biological nitrification and denitrification treatment systems are described below.

- ***Biological Treatment via Conventional Activated Sludge.*** Biological treatment uses microorganisms to consume, and thereby destroy, organic compounds as a food source. The organic compounds are used as both a carbon and energy source for these microbes. The microbes also require supplemental nutrients, such as ammonia and phosphorus, for growth. If ammonia removal is required, nitrification can be incorporated into an activated sludge biological treatment system. Nitrification is the aerobic process of converting ammonia to nitrite and then to nitrate. Biological treatment and nitrification is typically conducted in a conventional activated sludge system configured with an aeration tank, a clarifier, and return sludge equipment. Figure 8-12 presents a process flow diagram of a typical activated sludge biological treatment system. Diffused or mechanical aeration achieves the aerobic environment in the reactor and also serves to maintain the mixed liquor in a completely mixed regime. After a specified period of time, the mixture of new bacterial cells and old bacterial cells passes into a clarifier where the cells are separated from the treated wastewater. A portion of the settled cells is recycled to maintain the desired concentration of organisms in the reactor, and a portion is wasted.

In the nitrification process, the ammonium ion is converted to nitrate in two steps by autotrophic bacteria (*Nitrosomonas* and *Nitrobacter*, respectively), as summarized by the following reactions (Reference 8-12):



In addition to obtaining energy from the reaction shown above, the bacteria assimilate a portion of the nitrogen into the cell tissue as shown by the following reaction:



As shown in Equation 8-16, the nitrifying autotrophic bacteria use carbon dioxide and bicarbonate as a carbon source. Supplemental bicarbonate is introduced to the system through soda ash addition. Phosphorous is another key chemical required for biological growth. Biomass typically contains two percent phosphorous; therefore, phosphoric acid is normally added to the system as a nutrient.

The most important factor in controlling the activated sludge system is the sludge retention time (SRT). Industry data indicate that an SRT range of 50 to 100 days for cokemaking biological treatment is typical. Other significant factors affecting activated sludge systems include hydraulic retention time (HRT), the BOD₅/TKN (total Kjeldahl nitrogen) ratio, food-to-microorganism ratio (F/M), dissolved oxygen concentration (DO), temperature, and pH. Typical values for a few of these factors are shown below.

| HRT (hr) | F/M | Basin DO (mg/L) | Basin Temperature (°F) | Basin pH |
|----------|-----------|--------------------|----------------------------|-------------|
| 48 | 0.1 - 0.3 | 2 - 4 | 40 - 100 | 6 - 9 |

These factors, along with influent ammonia and nitrite concentrations, are important for nitrification. Biological treatment in the iron and steel industry is limited to treatment of cokemaking wastewater to remove nutrients and dissolved organic matter. By-product recovery cokemaking operations generate wastewater containing nutrients such as ammonia and dissolved organic matter, including phenols, VOCs, and PAHs. Biological treatment with nitrification can reduce organic concentrations to near non-detect; and can reduce ammonia concentrations in cokemaking wastewater to approximately 3 mg/L, as demonstrated by data provided in industry survey responses.

- **Biological Treatment via Sequencing Batch Reactor.** A sequencing batch reactor (SBR) is a fill-and-draw activated sludge system capable of treating the same types of wastewater as a conventional activated sludge system. The main difference is that conventional activated sludge systems treat the wastewater simultaneously in separate tanks, while an SBR system carries out the processes sequentially in the same reactor tank.

All SBR systems follow the sequence: fill, react, settle, draw, idle. Figure 8-13 illustrates the operation cycle of an SBR system. The fill step adds wastewater to the reactor and lasts approximately 25 percent of the full cycle time. Aeration begins during the react step. This step, similar to aeration tanks in a conventional activated sludge system, biodegrades organics and if operated to achieve nitrification, converts the ammonium ion to nitrate. The react step uses approximately 35 percent of the full cycle time. The settle step allows solids separation to occur, providing a clarified supernatant to be discharged as effluent. Settling accounts for approximately 20 percent of the full cycle time. The clarified, treated water is removed during the draw step. This step accounts for approximately 15 percent of the full cycle time. Idle is the last step. The purpose of the idle step in a multitank system is to provide time for one reactor to complete its fill cycle before switching to another unit. Sludge wasting also occurs during the idle step (Reference 8-14). Effective nitrification requires longer reaction and sludge retention times than for removal of only organic compounds.

SBR systems have many advantages over conventional activated sludge systems. An SBR tank serves as an equalization basin during the fill step and therefore can tolerate greater peak flows and/or shock loadings without degradation of effluent quality. The mixed liquor solids (biomass) cannot be washed out by hydraulic surges, since they can be held in the tank as long as necessary. Additionally, no return activated sludge pumping is required, because the mixed liquor is always in the reactor. The effluent quality of an SBR is also comparable to a conventional activated sludge system. However, because the discharge of effluent is periodic, it is possible, within limits, to hold the effluent until it meets specified requirements. Disadvantages to SBRs include the necessity of sophisticated timers and level sensors to control the process sequences and difficulties involved in controlling the draw step to minimize the discharge of floating or settled sludge. Also, aeration equipment can plug during the settle, draw, and idle steps.

- **Biological Treatment via Attached Growth/Fixed Film.** Attached growth/fixed film biological filtration is an alternative to a conventional activated sludge system or SBR. The biological processes for pollutant removals are the same; the difference is that the microorganisms adhere to

the surface of a rigid supporting media. Biological filtration systems also provide physical filtration, thereby removing solids from the wastewater.

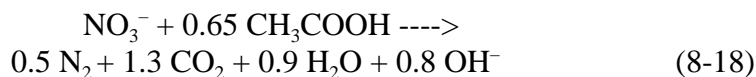
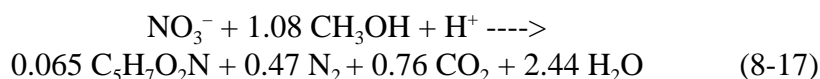
Wastewater enters the bottom of the filters through a feed distribution header and flows upward through the submerged media and support. Filter bed mediums and supporting materials may include granular particles, gravel, crushed stone, or other packing material. The microbes attached to the medium contact the wastewater and absorb organics and nitrogen for growth. The bed medium also filters out solids and suspended microorganisms. The biological filter must be periodically backwashed to prevent hindered wastewater flow. The backwash, consisting of solids and microorganisms, is settled in a clarifier or thickener. Benefits of biological filtration include dependability of the system, and a smaller design “foot print” than required by conventional activated sludge systems. However, biological filtration systems require proper attention to monitoring, maintenance, and backwash cycles to maximize efficiency, and are more costly than conventional activated sludge systems.

Effective nitrification in attached growth/fixed film systems requires longer contact times and lower hydraulic loading rates than for typical operation to remove organic compounds only. This is typically accomplished in the design of the biofiltration system. Deeper biofiltration beds increase contact time, thereby, enhancing nitrification.

- **Biological Denitrification.** Denitrification is a metabolic process in which nitrate is converted to nitrogen gas in the presence of a combined hydrogen source and a lack of free oxygen. The bacteria that reduce nitrate are facultative heterotrophs of the genera *Pseudomonas*, *Micrococcus*, *Achromobacter*, and *Bacillus* (Reference 8-12). The reaction involves the transfer of electrons from organic carbon (oxidation) to nitrate (reduction) promoting its conversion to nitrogen gas. The biochemical pathway in which nitrate is substituted for oxygen as the final electron acceptor in the electron transport chain is thermodynamically less favorable than if oxygen were the final electron acceptor. In the presence of free oxygen, denitrification ceases and typical aerobic oxidation predominates. Denitrification is typically referred to as anoxic respiration since it is an aerobic process in the absence of free oxygen.

The anoxic process, like the aerobic process, utilizes organic carbon to maintain cellular respiration and synthesis of biomass. The carbon can be derived from either the endogenous decay of biomass or from an external source, such as added methanol or organic materials already in the waste. The majority of denitrification systems operating in the United States use methanol as their carbon source. The equations below show the balanced stoichiometric reactions for converting nitrate to nitrogen gas with either

methanol (Equation 8-17) or acetic acid (Equation 8-18) as the carbon source (Reference 8-15).



Biological denitrification (anaerobic) can be used to treat cokemaking wastewater following biological nitrification. For denitrification of cokemaking wastewater, two treatment options are applicable: 1) an end-of-pipe unit in which all the flow from the biological nitrification system enters the denitrification system; or 2) a recycle system in which a portion of the effluent from the biological nitrification system is returned to the beginning of the treatment system and mixed with untreated wastewater. Figure 8-14 presents denitrification systems. For the end-of-pipe denitrification system, a supplemental carbon source such as methanol is required to convert nitrate to nitrogen gas. For the recycle system, recycle equipment and tanks are required to handle recycle volumes approximately 3 to 4 times the original wastewater flow.

8.3.3 Sludge Handling

Solids are removed by a number of the treatment technologies used by the iron and steel industry including 1) biological treatment and cyanide precipitation of cokemaking wastewater, 2) clarifiers for treatment of high-rate recycle water in the ironmaking and steelmaking processes, including backwash from multimedia filters, and 3) chemical precipitation and multimedia filtration of high-rate recycle blowdown and steel finishing process waters for metals removal, including backwash from multimedia filters. Dilute sludges from each of these processes are often concentrated by gravity thickening prior to dewatering by a variety of presses and filters. Filter cake collected from the dewatering equipment may be further processed by sludge dryers to remove additional moisture. The following paragraphs describe the technologies used to reduce the volume of treatment sludges generated by iron and steel facilities.

- **Gravity Thickening.** Gravity thickening is a physical liquid-solid separation technology commonly used by the industry to dewater wastewater treatment sludge. Figure 8-15 shows a typical gravity thickener. Sludge is fed from a primary settling tank or clarifier to a thickening tank, where gravity separates the supernatant from the sludge, increasing the sludge density. The supernatant is returned to the primary settling tank. The thickened sludge that collects on the bottom of the tank is pumped to additional dewatering equipment or contract hauled for disposal.

Gravity thickeners are generally used by facilities where the sludge is to be further dewatered by a mechanical device, such as a filter press.

Increasing the solids content in the thickener substantially reduces capital and operating costs of the subsequent dewatering device and also reduces the hauling cost. Typically, gravity thickeners produce sludge with 8 to 10 percent solids by weight (Reference 8-16). Thickening is not a viable technology for sludges that have a consistency that hinders thickening. Gravity thickeners are commonly used in all iron and steel industry wastewater treatment systems to thicken dilute sludge.

- **Rotary Vacuum Filtration.** Rotary vacuum filtration is commonly used in the industry for sludge dewatering. The rotary vacuum precoat filter consists of a perforated plate steel drum deck covered with a filter cloth. A diatomaceous earth precoat is used to prevent small suspended particles from passing through the filter and into the center of the drum where filtrate is removed. A scraper is used to shave filter cake from the surface of the diatomaceous earth precoat filter, preventing the filter cake from reaching a thickness that would not adhere to the filter. Figure 8-16 depicts a rotary vacuum filter. Rotary drum filters typically rotate between 0.25 and 6.5 revolutions per minute (RPMs), depending on the concentration of suspended solids in the wastewater (Reference 8-12). Filtrate that passes through the filter cake and diatomaceous earth precoat enters the center of the vacuum drum and is collected in horizontal pipes connected to a center drain shaft. Solids collected from ironmaking rotary vacuum filters can be recycled to sintering operations to recover iron. The performance and the life of the filter depend on the filter medium. Also, if the cake is not removed properly from the filter, the cake build-up will eventually cause the filter to clog. Rotary vacuum filters are commonly used in the iron and steel industry to dewater sludges from blast furnace and sintering treatment systems.
- **Pressure Filtration.** The plate-and-frame filter press is commonly used for sludge dewatering in the iron and steel industry. Figure 8-17 illustrates a plate-and-frame filter press. A filter press consists of a series of parallel plates pressed together by a hydraulic ram (older models may have a hand crank), with cavities between the plates. The filter press plates are covered with a filter cloth and are concave on each side to form cavities. At the start of a cycle, a hydraulic pump clamps the plates tightly together and a feed pump forces a sludge slurry into the cavities of the plates. The liquid (filtrate) escapes through the filter cloth and grooves molded into the plates and is transported by the pressure of the feed pump (typically around 100 psi) to a discharge port. The solids are retained by the cloth and remain in the cavities. This process continues until the cavities are packed with sludge solids. An air blow-down manifold is used on some units at the end of the filtration cycle to drain remaining liquid from the

system, thereby improving sludge dryness and aiding in the release of the cake. The pressure is then released and the plates are separated.

The sludge solids or cake is loosened from the cavities and falls into a hopper or drum. A plate filter press can produce a sludge cake with a dryness of approximately 25 to 40 percent solids for metal hydroxides precipitated with sodium hydroxide (caustic), and 35 to 60 percent solids for metal hydroxides precipitated with calcium hydroxide (lime). The solids content attained depends on the length of the drying cycle. Filter presses are available in a wide range of capacities (0.6 ft³ to 20 ft³). A typical operating cycle is from 4 to 8 hours, depending on the dewatering characteristics of the sludge. Units are usually sized based on one or two cycles per day (Reference 8-12). The maintenance requirements of a plate filter press are lower than other sludge dewatering technologies. However, plate filter presses are more expensive and are operated in batches; therefore, sludge must be held between batches. Plate filter presses are commonly used in the iron and steel industry to dewater sludges from steelmaking and steel finishing treatment systems.

- **Belt Filtration.** The belt pressure filter consists of two continuous belts set one above the other. Sludge is fed in between the two belts. Three process zones exist. First, the sludge passes through the drainage zone where dewatering is effected by the force of gravity. Then, the sludge passes into the pressure zone where pressure is applied to the sludge by means of rollers in contact with the top belt. Finally, the sludge is passed to the shear zone where shear forces are used to bring about the final dewatering. The dewatered sludge is then removed by a scraper. Belt filtration can produce a sludge cake with a dryness of approximately 25 to 30 percent solids (Reference 8-17). Belt filters produce very dry cake, low power requirement, and continuous operation. The main disadvantages are short media life and a filtration rate sensitive to incoming sludge. Plate filter presses are commonly used in the iron and steel industry to dewater by-product recovery cokemaking biological treatment sludges.
- **Centrifugation.** A sludge dewatering device collects wet sludge in a cone-shaped drum. The drum is rotated to generate centrifugal forces to concentrate solids to the walls of the drum. These solids are continually removed from the centrifuge by an auger, screw conveyor, or similar device. Centrifugation dewateres sludges, reducing the volume and creating a semi-solid cake. Centrifugation of sludge can typically achieve a sludge of 20 to 35 percent solids (Reference 8-12). Centrifuges are compact, need little space, and can handle sludges that might otherwise plug filter cloth. The disadvantages include complexity of maintenance, abrasion problems, and centrate (liquid) high in suspended solids. Centrifuges are

infrequently used in the iron and steel industry to dewater sludges from blast furnace, steelmaking, and finishing treatment systems.

- **Sludge Drying.** Wastewater treatment sludges are often hauled off site to disposal sites. The transportation and disposal costs depend primarily on the volume of sludge. Therefore, sludge dehydration following dewatering can further reduce the volume of the sludge and the overall disposal cost. The solids content of the sludge dewatered on a filter press is usually in the range of 25 to 60 percent. Dehydration equipment can produce a waste material with a solids content of approximately 90 percent (Reference 8-12).

There are several design variations for sludge dehydration equipment. A commonly used type is a sludge drying unit that uses an auger or conveyor system to move a thin layer of sludge through a drying region and discharge it into a hopper. Various heat sources are used for sludge drying, including electric, electric infrared, steam, and gas. Some continuous units are designed such that the sludge cake discharge from a filter press drops into the feed hopper of the dehydration unit, making the overall dewatering process more automated. System capacities range from less than 1 ft³/hr to more than 20 ft³/hr of feed. Sludge dehydration equipment requires an air exhaust system due to the fumes generated during drying. Energy requirements for sludge drying can be costly, but depend on the water content of the sludge and the efficiency of a given unit. Sludge drying are infrequently used in the iron and steel industry to dewater sludges from steelmaking and steel finishing treatment systems.

8.4 Best Management Practices (BMPs)

There are many plant maintenance and good housekeeping management practices used at iron and steel facilities that reduce the need for treatment, which saves costs: routine monitoring, training and supervision, production planning and sequencing, process or equipment modification, raw material and product substitution or elimination, and loss prevention and housekeeping (Reference 8-18). These alternatives are discussed below:

- **Routine Monitoring.** Routine monitoring and record keeping of pollutants and treatment systems performance enables sites to continuously evaluate treatment system performance and detect and remediate problems early. For example, cokemaking facilities analyze effluent wastewater samples for total phenolics as part of a daily monitoring routine to help identify and respond to potential upset conditions.
- **Flow Management.** Good flow management practices reduce pollutant discharges to receiving waters or a POTW. Controlling and treating runoff

from raw material storage piles, EAF dust collection areas, and blast furnace and steelmaking slag processing sites is important. Managing of storm water from process areas through collection and treatment, use as makeup water, or use as control water for cokemaking biological treatment reduces pollutant discharges to adjacent water bodies. Also control and treatment of leachate and groundwater contamination from blast furnace slag pits and coke batteries, coke quench tower sumps, and by-product recovery areas should be addressed. Cascade of blowdowns from compatible noncontact cooling water and water recycle systems minimizes wastewater treatment requirements. Good flow control of rinse water flow rates minimizes wastewater generation and discharge.

- ***Training and Supervision.*** Training and supervision ensures that employees are aware of, understand, and support the company's waste minimization goals. These goals are translated into practical information that will enable employees to minimize waste generation by properly and efficiently using tools, supplies, equipment, and materials.
- ***Production Planning and Sequencing.*** Production is planned to minimize the number of processing steps and eliminate unnecessary procedures (e.g., plan production to eliminate additional cleaning steps between incompatible operations).
- ***Process or Equipment Modification.*** Processes and equipment are modified to minimize the amount of waste generated (e.g., reducing drag-out by slowing the withdrawal speed of the product, installing electrolytic recovery units).
- ***Raw Material and Product Substitution or Elimination.*** Where possible, raw materials or products are replaced with other materials that produce either less waste and/or less toxic waste (e.g., replacing chromium-bearing solutions with non-chromium-bearing and less toxic solutions, consolidating types of cleaning solutions and machining coolants).
- ***Oil Management and Preventive Maintenance.*** Where possible, sites remove oil in wastewater recirculation systems, recycle used oil, and ensure integrity of process area containment systems. Sites should have surveillance and corrective action programs for oil discharges from large noncontact cooling water flows.
- ***Loss Prevention and Housekeeping.*** Preventive maintenance and managing equipment and materials minimizes leaks, spills, evaporative losses, and other releases. Examples include inspecting the integrity of tanks on a regular basis, using chemical analyses instead of elapsed time or amount of product processed as the basis for disposal of a solution, and

controlling spillage from loading stations for rolling solutions and pickling acids. Solution testing is one important loss prevention alternative. The chemical makeup of cleaning solutions changes over time due to evaporative losses, water addition, drag-out of cleaning chemicals, consumption of bath chemistry, chemical reactions, and drag-in of impurities. Because of these factors, cleaning baths lose strength, performance declines, and solutions require disposal. Many sites operate cleaning baths with a schedule consisting of three steps: formulate, use, and discard. This procedure can be expensive and inefficient from a production standpoint, and creates large volumes of waste. For this reason, sites should frequently determine the strength of the cleaning solution and appropriate chemical additions needed to prolong solution use. By implementing a program of testing and record keeping, sites can reduce the disposal frequency of cleaning baths.

- ***Waste Segregation and Separation.*** Mixing different types of wastes or mixing hazardous wastes with nonhazardous wastes is avoided. Recyclable materials are not mixed with incompatible materials or wastes. For example, hexavalent-chromium-bearing wastewater is segregated for pretreatment.

8.5 **References**

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Table 8-1

Wastewater Minimization, Pollution Prevention, and Process Modification Technologies

| Technology | Description | Applicable Subcategories |
|---|---|--|
| Wastewater Minimization and Pollution Prevention | | |
| High-rate recycle of wastewater | A closed loop system that recycles approximately 95 percent or more of water for reuse. Typically used in conjunction with treatment to allow more water to be reused. High-rate recycle is well demonstrated in each of the applicable subcategories. | Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Other Operations |
| Countercurrent cascade rinsing | Cascading rinsing system that uses consecutive rinse tank to reduce the amount of water necessary for rinsing. | Steel Finishing |
| Fume scrubber recycle | Wet air pollution control system used to capture acid gases. Water is neutralized and continuously recirculated. This system can significantly reduce the volume of water discharged from WAPC equipment. | Steel Finishing |
| Hydrochloric acid regeneration | Hydrochloric acid recovery system that heats spent pickle liquor to decompose iron oxide into ferric oxide and hydrogen chloride (HCl). The HCl is reabsorbed in water and returned to the process bath. The process reduces the amount of spent acid generated by the facility. Also reduces the amount of neutralization treatment chemicals needed and the mass of chlorides discharged. | Steel Finishing |
| Sulfuric acid recovery | Sulfuric acid recovery system that precipitates and removes iron as ferrous sulfate from the spent pickle liquor. The resulting sulfuric acid can be returned to the process bath. This process reduces the amount of spent acid generated by the facility. Also reduces the amount of neutralization treatment chemicals needed and the mass of sulfates discharged. | Steel Finishing |
| Acid purification and recycle | Nitric/hydrofluoric acid is purified by adsorption on a bed of alkaline anion exchange resin that separates the acid from metal ions. Acid is desorbed from the resin with water and returned to the process bath. This process can reduce the amount of spent acid generated by the facility. Also reduces the amount of neutralization treatment chemicals needed and the mass of anions such as nitrate, sulfate, and fluoride discharged. | Steel Finishing |

Table 8-1 (Continued)

| Technology | Description | Applicable Subcategories |
|--|---|--|
| Wastewater Minimization and Pollution Prevention (continued) | | |
| In-tank filtration | Paper, cloth, cartridge, or plastic filters used to extend process bath life or to remove solids from cold rolling solutions. | Steel Finishing |
| Magnetic separation of fines in cold rolling solution | Magnetic separators are installed in rolling solution collection tanks or in a side-stream system to extend the life of rolling solutions. | Steel Finishing |
| Evaporation with condensate recovery | Energy-intensive and can have cross-media impacts. Not included in the technology options. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing |
| Process Modifications | | |
| Effluent-free pickling process with fluid bed hydrochloric acid regeneration | Uses both the hydrochloric acid regeneration system and fume scrubber water to achieve zero discharge for hydrochloric acid pickling operations. A fluidized bed reactor is used to regenerate the acid (see description above). Fume scrubber water, used to cool the fluidized bed off-gases, is evaporated rather than blown down to end-of-pipe treatment. | Steel Finishing |
| Nitric-acid-free pickling | This proprietary technology uses a nitric-acid free solution containing an inorganic mineral base, hydrogen peroxide, stabilizing agents, wetting agents, brighteners, and inhibitors for stainless steel pickling/ This system can reduce the amount of nitrate/nitrite generated by the facility. | Steel Finishing |
| Effluent-free exhaust cleaning | Exhaust gases from stainless steel pickling are treated by a selective catalytic reduction (SCR) technology in lieu of a wet air pollution control device. Anhydrous ammonia is injected into the gas stream prior to a catalyst to reduce NO _x to nitrogen and water. This would eliminate wastewater generated from scrubbing of exhaust gases from stainless steel pickling operations. | Steel Finishing |

Table 8-2**Wastewater Treatment and Sludge Handling Technologies**

| Technology | Description | Applicable Subcategories |
|---|---|---|
| Physical/Chemical Treatment | | |
| Equalization | Tank that dampens fluctuations in flow and influent wastewater quality. Equalization will enhance performance of downstream equipment. Equalization is an end-of-pipe treatment technology. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Tar removal | Recovers tar and oil through settling. This technology is demonstrated in the cokemaking industry, and improves the performance of free and fixed ammonia stills. Tar removal is an end-of-pipe treatment technology. | Cokemaking |
| Free and fixed ammonia distillation (stripping) | A column is used to remove ammonia with steam to transfer from the ammonia from liquid to the gas phase. Free ammonia is removed first, followed by conversion of fixed ammonia to free ammonia (using sodium hydroxide or soda ash), and subsequently removed. Free and fixed ammonia distillation is an end-of-pipe treatment technology. | Cokemaking |
| Cooling towers | Cooling towers control water temperature through contact of air with the water. Cooling towers are used in both in-process and end-of-pipe treatment systems. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Other Operations |
| Shell-and-tube heat exchangers | Indirect contact device that transfers heat from one fluid to another. Shell-and-tube heat exchangers are most common. Heat exchangers are used in end-of-pipe treatment systems. | Cokemaking |
| Alkaline chlorination/ breakpoint chlorination | Alkaline chlorination oxidizes cyanide with incidental removals of ammonia and phenolics. Cyanide is converted to cyanate and then to bicarbonate and nitrogen using chlorine or sodium hypochlorite. Breakpoint chlorination targets ammonia with incidental removals of cyanide and phenolics. Ammonia is oxidized to nitrogen using chlorine or sodium hypochlorite. These technologies are end-of-pipe systems. | Cokemaking Ironmaking |

Table 8-2 (Continued)

| Technology | Description | Applicable Subcategories |
|--|---|---|
| Physical/Chemical Treatment (continued) | | |
| Cyanide precipitation | Proprietary technology that adds iron to cyanide-laden wastewater to precipitate an insoluble iron-cyanide complex. Cyanide precipitation is an end-of-pipe treatment technology. | Cokemaking |
| Ozone oxidation | Ozone oxidizes cyanide to bicarbonate and nitrogen. Ozone also oxidizes other iron and steel pollutants of concern, such as ammonia and organic compounds. This technology is considered end-of-pipe treatment. | Cokemaking Ironmaking |
| Gravity flotation | Nonemulsified oil is allowed to rise to the surface of the wastewater and is removed by an oil skimmer. Typical skimming devices include disk, belt, and drum skimmers. Gravity flotation is used for in-process and end-of-pipe treatment. | Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing |
| Oil/water separation | Wastewater containing nonemulsified oil enters a basin with inclined plates that trap the oil for removal. An API separator is the most common type of oil/water separator. Oil/water separators are typically used for end-of-pipe treatment. | Steel Finishing Other Operations |
| Chemical emulsion breaking and dissolved air flotation | Chemical emulsion breaking (CEB) is used for emulsified oily wastewaters. Chemicals are added to a mix tank to break the emulsions. Typically CEB is followed by dissolved air flotation (DAF) which injects air into the wastewater to cause the oil to rise to the surface. The oil can then be mechanically removed. CEB and DAF are end-of-pipe treatment technologies. | Steel Finishing |
| Ultrafiltration | Ultrafiltration is a pressure-driven membrane process to separate emulsified oils from wastewater without CEB. Ultrafiltration is an end-of-pipe treatment technology. | Steel Finishing |
| Carbon dioxide injection | Carbon dioxide is injected into the wastewater to remove hardness and regulate pH of wet-open and wet-suppressed BOF recycle systems. This allows more water to be reused in the recycle system. Carbon dioxide injection is used as part of in-process treatment. | Integrated Steelmaking |

Table 8-2 (Continued)

| Technology | Description | Applicable Subcategories |
|--|--|---|
| Physical/Chemical Treatment (continued) | | |
| Hexavalent chromium reduction | Hexavalent chromium is reduced using sulfur dioxide, sodium bisulfite, sodium metabisulfite, or ferrous sulfate. Reduction allows chromium to be removed from solution by subsequent chemical precipitation. This is an end-of-pipe treatment technology. | Steel Finishing |
| Chemical precipitation | Removes metals from wastewater by converting soluble metals to insoluble salts. Typically lime, caustic, or magnesium hydroxide is used as the precipitant. Chemical precipitation is an end-of-pipe treatment technology. | Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Ion exchange | Ion exchange is a reversible chemical reaction that exchanges ions in wastewater for ions of like charge on the surface of the ion exchange resin. When the resin is regenerated, the captured ions are concentrated and removed for disposal or reuse. Metals from plating rinses can be recovered using ion exchange. This can be an in-process or end-of-pipe treatment technology. | Steel Finishing |
| Scale pits with oil skimming | Scale pits are used for primary sedimentation of large particles from wastewater. This technology is typically used in high-rate recycle systems. Therefore, this is an in-process technology. | Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming |
| Classifiers | Classifiers use screw or rake systems for primary solids removal in recycle systems. Therefore, this is an in-process technology. | Integrated Steelmaking Other Operations |
| Clarification/sedimentation | Solids are removed by gravity sedimentation in clarifiers. Clarifiers may be either rectangular or circular and are designed with a hydraulic residence time sufficient for solids removal. This technology can be used with both in-process or end-of-pipe treatment systems. | Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |

Table 8-2 (Continued)

| Technology | Description | Applicable Subcategories |
|---|---|---|
| Physical/Chemical Treatment (continued) | | |
| Microfiltration | Solids are separated from wastewater using a pressure-driven membrane process. This technology can be used with both in-process or end-of-pipe treatment systems. | Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Multimedia filtration | Multimedia filtration uses a bed of granular particles as the filter medium for solids removal. When the pressure drop across the filter is large enough to impede flow, it is cleaned by forcing wash water through the bed in the reverse direction of original wastewater flow. Multimedia filtration can be used as in-process or end-of-pipe treatment. Also called mixed-media filtration. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Granular activated carbon (GAC) | GAC removes dissolved organic compounds from wastewater streams via adsorption. The organic compound collects on and adheres (bond) to the surface of the carbon. When all bonding sites are occupied, the carbon is considered "spent" and must be regenerated to remove the accumulation organic compounds. GAC is an end-of-pipe treatment technology. | Cokemaking Ironmaking |
| Biological Treatment | | |
| Biological nitrification using conventional activated sludge | Biological nitrification uses microorganisms to convert ammonia to nitrate in an aerobic environment using a conventional activated sludge system. Wastewater and the microorganisms are aerated in a reactor for a specified period of time and then settled in a clarification unit. A portion of the microorganisms are recirculated to the reactor, and a portion is wasted. This is an end-of-pipe treatment technology. | Cokemaking |
| Biological nitrification using sequencing batch reactors (SBRs) | SBRs use the same biological processes as a conventional activated sludge biological nitrification system. The difference is that all steps of the process are carried out in one tank. An SBR is an end-of-pipe treatment technology. | Cokemaking |

Table 8-2 (Continued)

| Technology | Description | Applicable Subcategories |
|--|--|---|
| Biological Treatment (continued) | | |
| Biological nitrification using attached growth | Attached growth systems use the same biological processes as a conventional activated sludge biological nitrification system. The difference is that the microbes are attached to a rigid supporting media. An attached growth system is an end-of-pipe treatment technology. | Cokemaking |
| Biological denitrification | Denitrification also uses the metabolic processes of microorganisms to convert nitrate to nitrogen gas. This process must be conducted in the absence of oxygen for denitrification to occur. This is an end-of-pipe treatment technology. | Cokemaking |
| Sludge Treatment and Disposal | | |
| Gravity thickening | Sludge is fed from a clarifier or settling tank into the thickener where gravity separates the supernatant from the sludge, increasing the sludge density. The thickened sludge is further dewatered by other equipment or disposed. Thickening can dewater sludge from in-process or end-of-pipe treatment systems. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Rotary vacuum filtration | A rotary vacuum filter consists of a perforated plate steel drum covered with a filter cloth. A diatomaceous earth precoat is used to prevent small suspended particles from passing through the filter to the center of the drum where filtrate is removed. The drum picks up sludge as it rotates. A scraper is used to remove filter cake from the surface of the earth precoat to prevent a thickness that would not adhere to the filter. Rotary vacuum filtration can dewater sludge from in-process or end-of-pipe treatment systems. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Pressure filtration | A series of parallel plates, covered with filter cloth, are filled with sludge and then pressed together by a hydraulic ram. The liquid (filtrate) escapes through the filter cloth while the solids are retained. The sludge is then collected in a hopper or drum for disposal. Pressure filtration can dewater sludge from in-process or end-of-pipe treatment systems. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |

Table 8-2 (Continued)

| Technology | Description | Applicable Subcategories |
|--|--|---|
| Sludge Treatment and Disposal (continued) | | |
| Belt filtration | Sludge is fed between two continuous belts set one above another. The sludge passes through three process zones: the drainage zone (dewatering by gravity), pressure zone (dewatering by pressure of rollers on the belts), and the shear zone (final dewatering through shear forces). The dewatered sludge is removed by a scraper. Belt filters are typically used to dewater sludge from an end-of-pipe biological treatment system. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Centrifugation | Sludge is pumped into a cone-shaped drum. The drum is rotated to generate centrifugal forces to concentrate solids to the walls of the drum. These solids are continuously removed by an auger, or screw conveyer. Centrifuges can dewater sludge from in-process or end-of-pipe treatment systems. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Sludge drying | Sludge is heated to remove excess liquid. Various design variations exist; the most common sludge drying unit uses an auger or conveyor to move a thin layer of sludge through a drying region and discharge it to a hopper. Sludge drying can dewater sludge from in-process or end-of-pipe treatment systems. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing Other Operations |
| Best Management Practices | | |
| Best management practices | Many plant maintenance and good housekeeping management practices can reduce wastewater or pollutant generation, and the need for treatment, and help maximize process efficiency. | Cokemaking Ironmaking Integrated Steelmaking Integrated and Stand-Alone Hot Forming Non-Integrated Steelmaking and Hot Forming Steel Finishing |

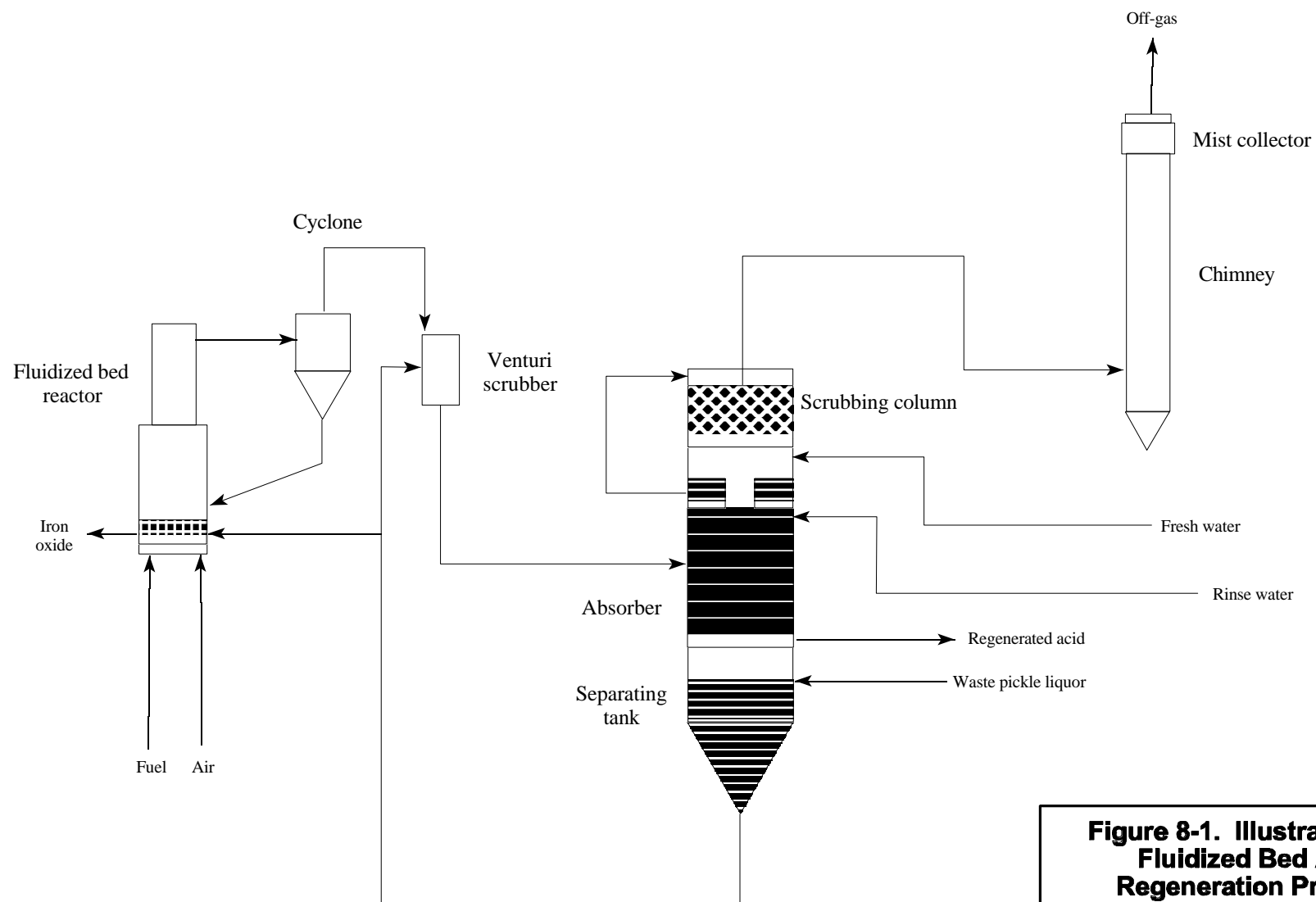


Figure 8-1. Illustration of a Fluidized Bed Acid Regeneration Process

Regen

3/27/02



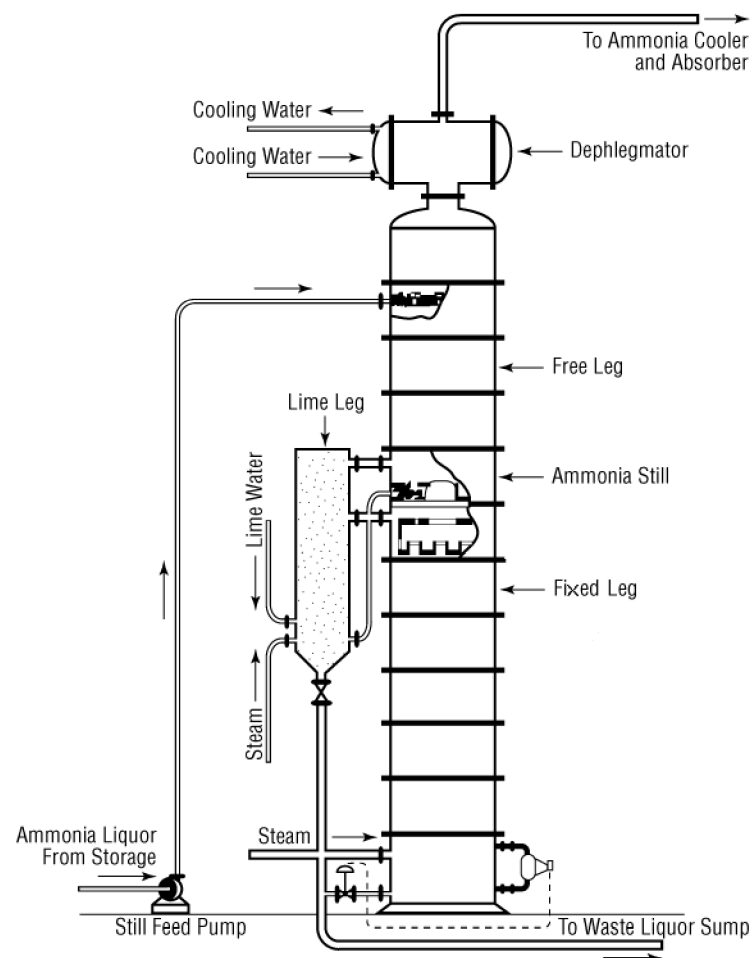


Figure 8-2. Typical Free and Fixed Ammonia Distillation Column

Sources: Site visit, U.S. Steel Gary Works, Gary, Indiana.
 Association of Iron and Steel Engineers, *The Making, Shaping, and Treating of Steel*,
 ISBN 0-930767-00-4; Pittsburgh, PA; 1985.

ASTill

11/05/01



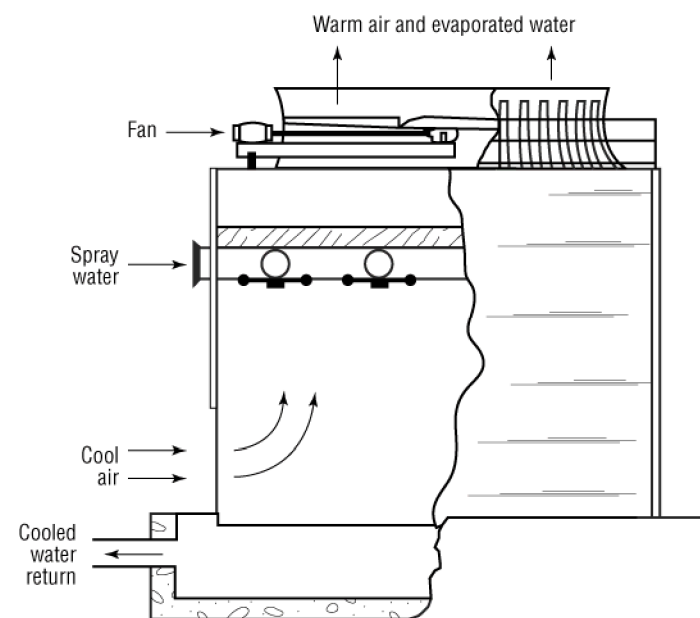
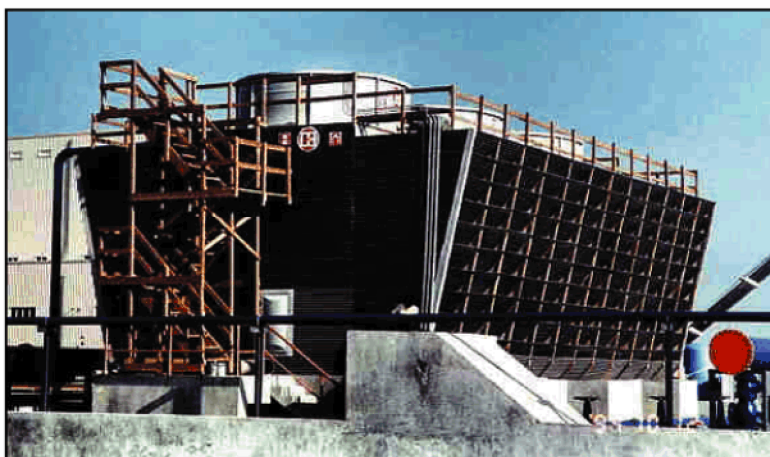


Figure 8-3. Typical Cooling Tower

Sources: Davis & Spence Pty Ltd. Cooling Tower. <http://www.davisandspence.com.au/photo.htm>.,
 Marley Cooling Towers. Cooling Tower Performance: Basic Theory and Practice.
http://www.marleyct.com/pdf_forms/CTII-1.pdf

CTower

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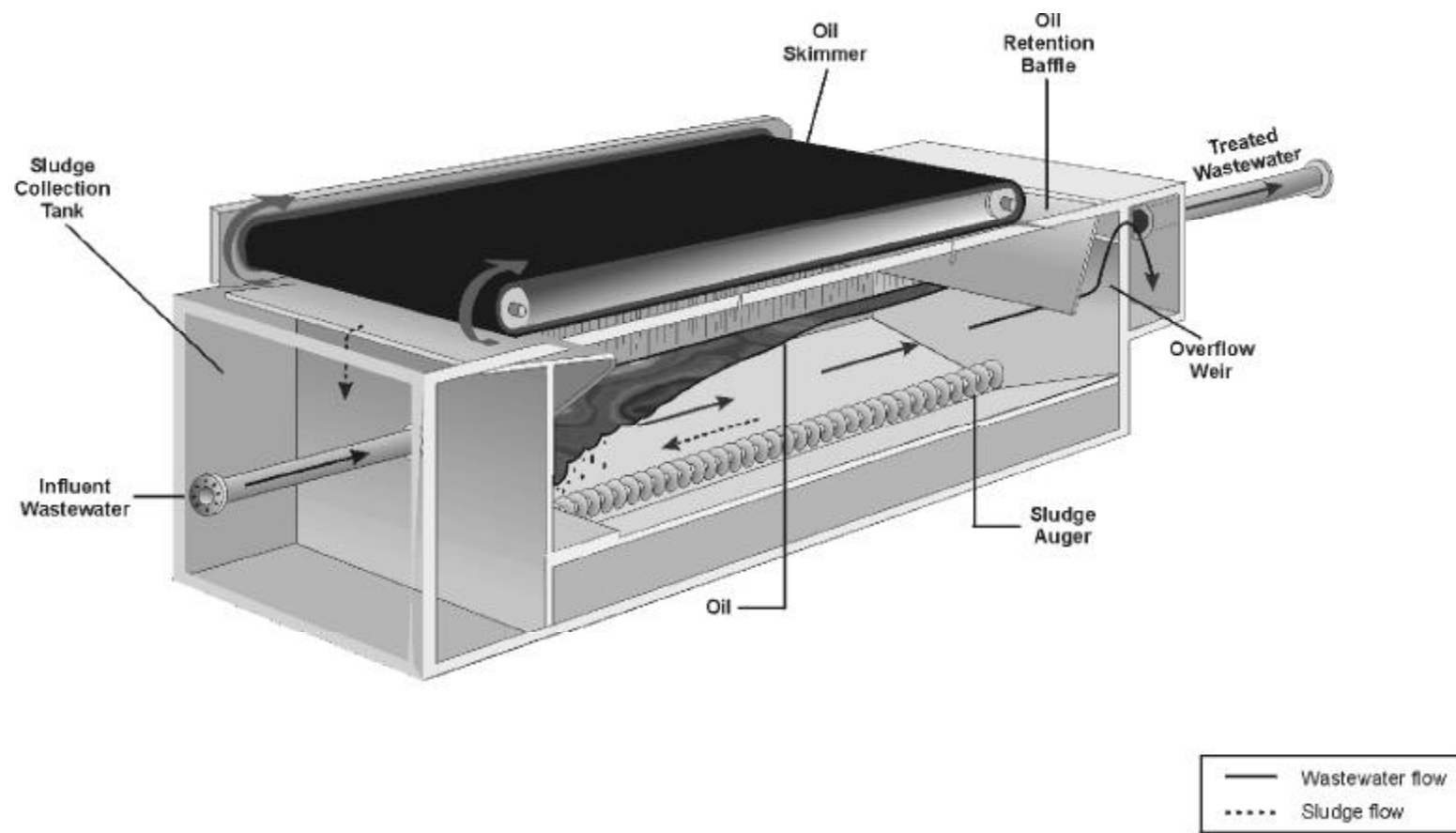


Figure 8-4. Typical Oil/Water Separator

O/WSep

10/03/00



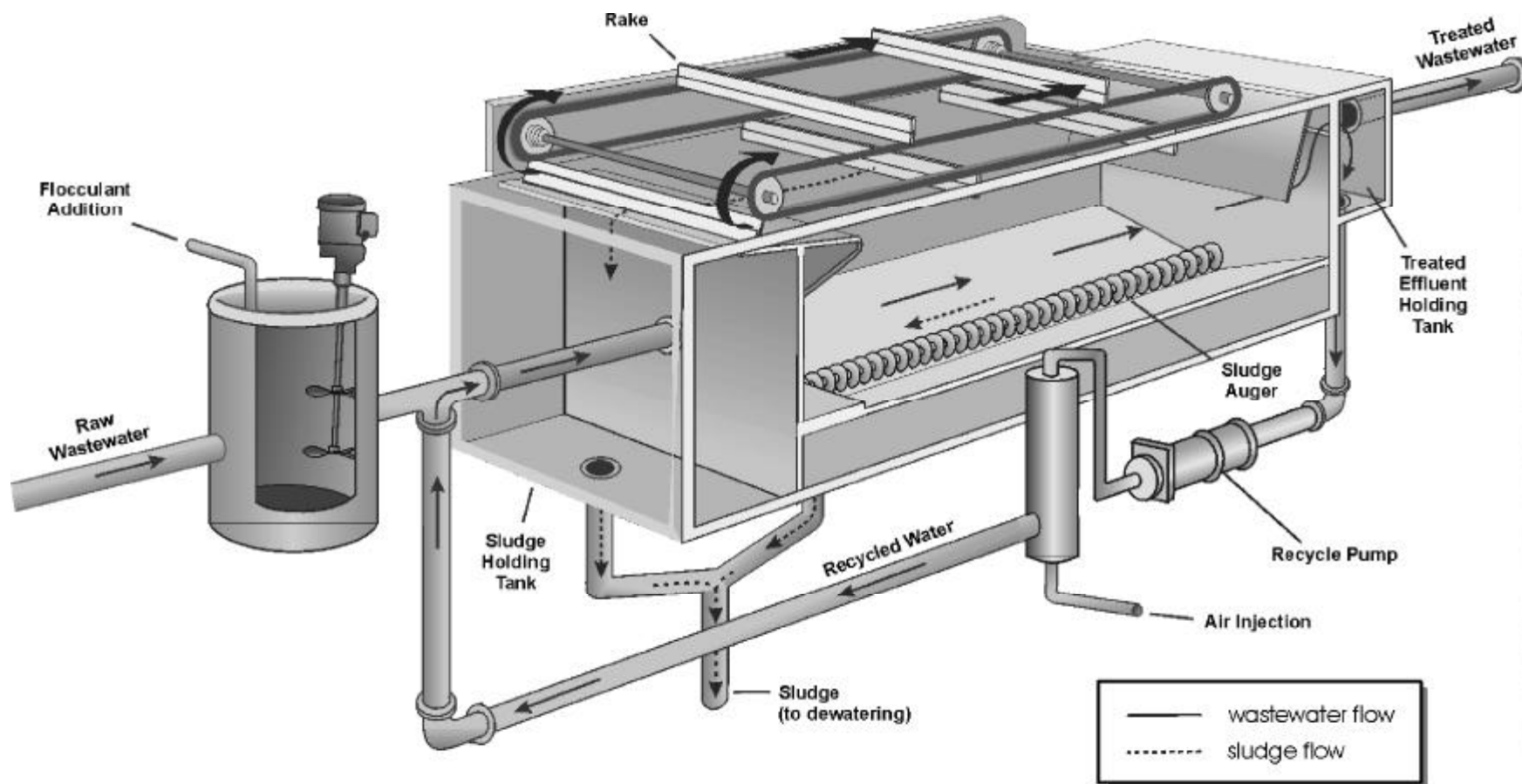


Figure 8-5. Typical Dissolved Air Flotation System

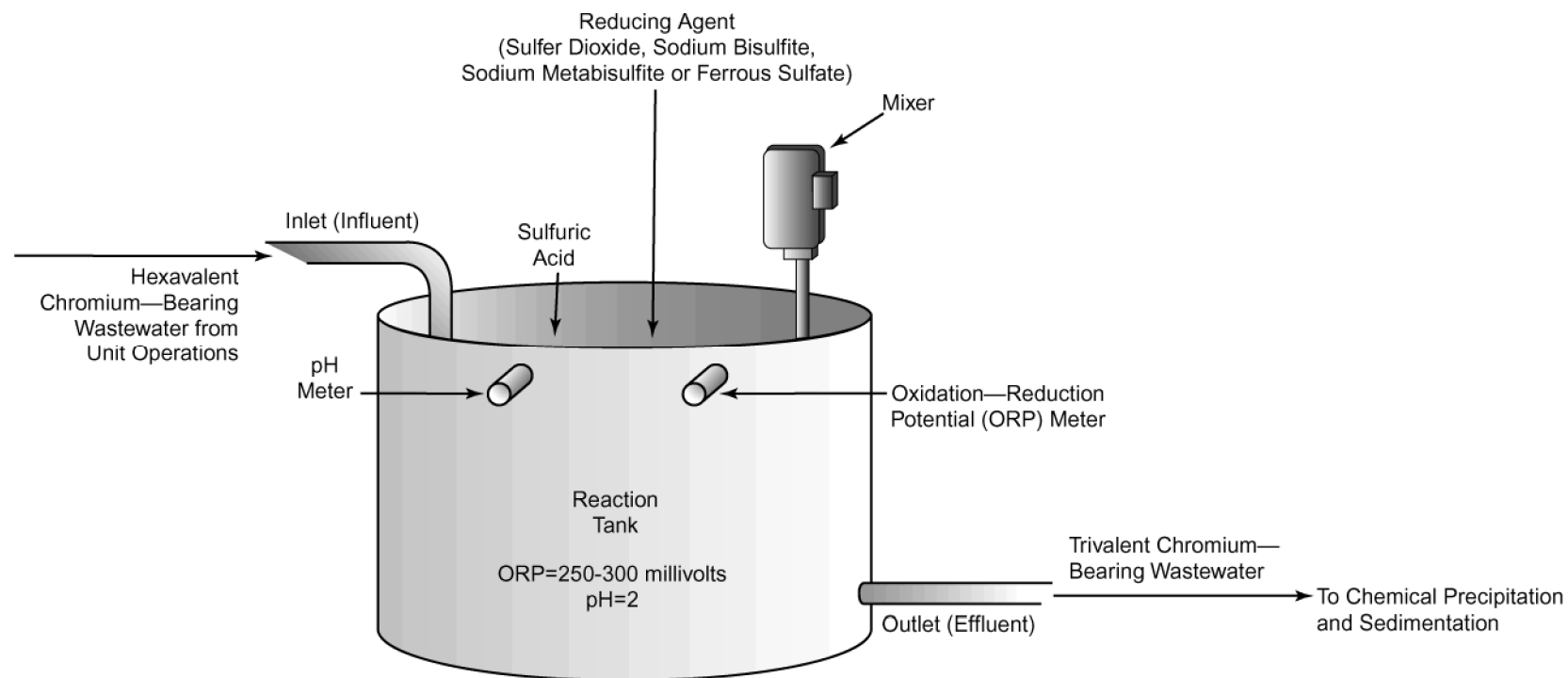


Figure 8-6. Typical Hexavalent Chromium Reduction System

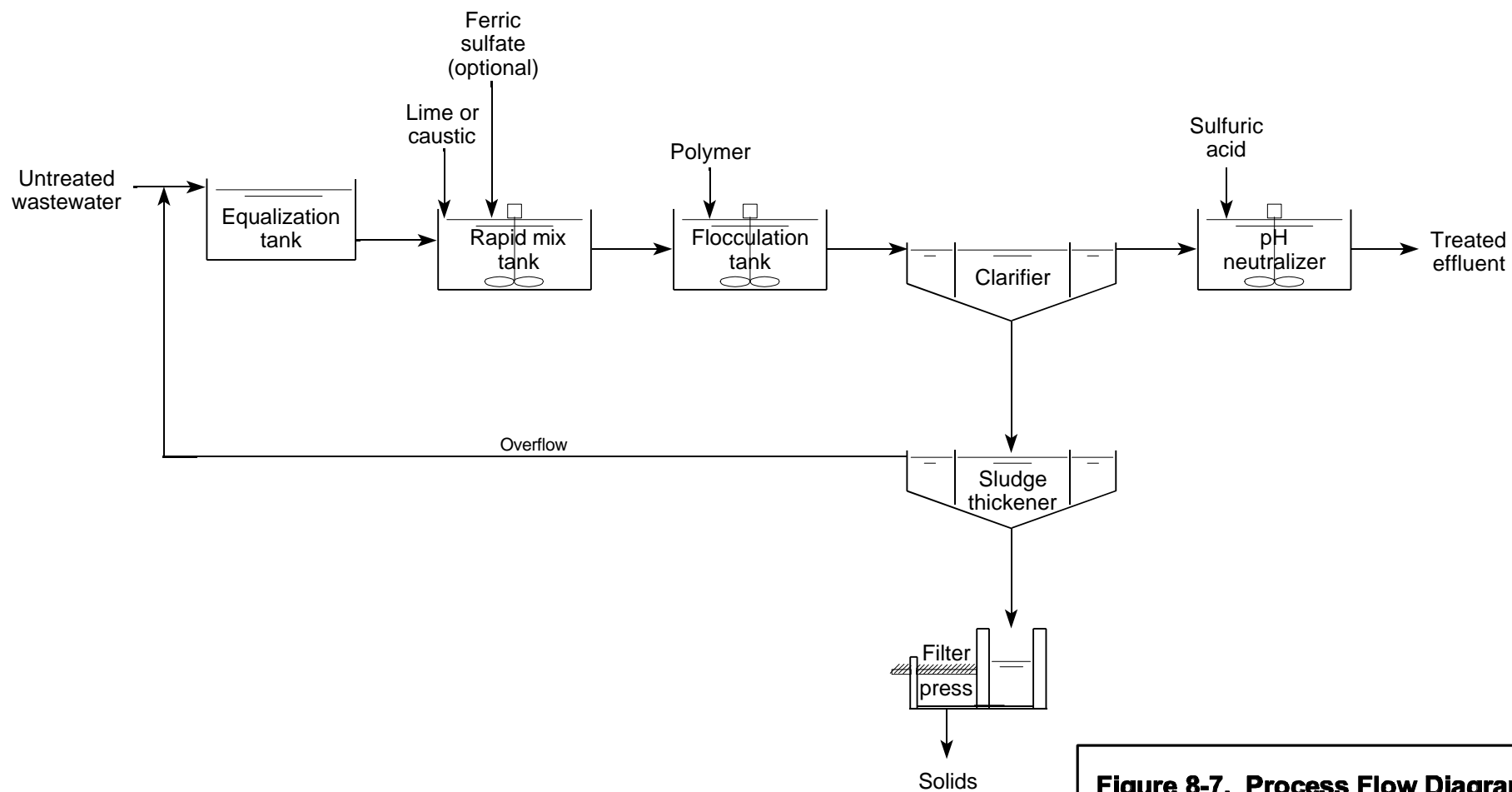


Figure 8-7. Process Flow Diagram of a Typical Chemical Precipitation System for Metals Removal

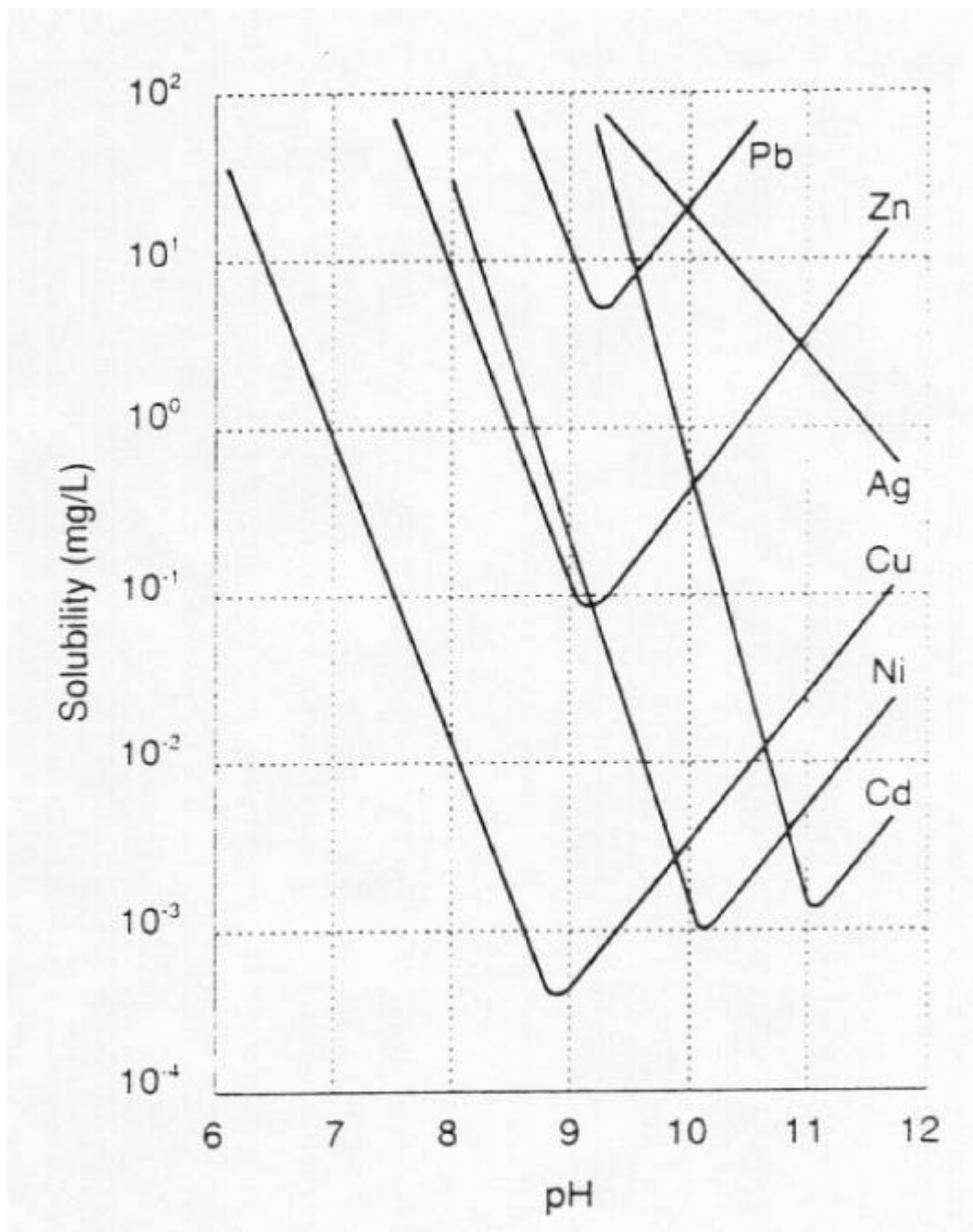


Figure 8-8. Minimum Solubilities of Various Metals Hydroxides

Solubility

10/03/00



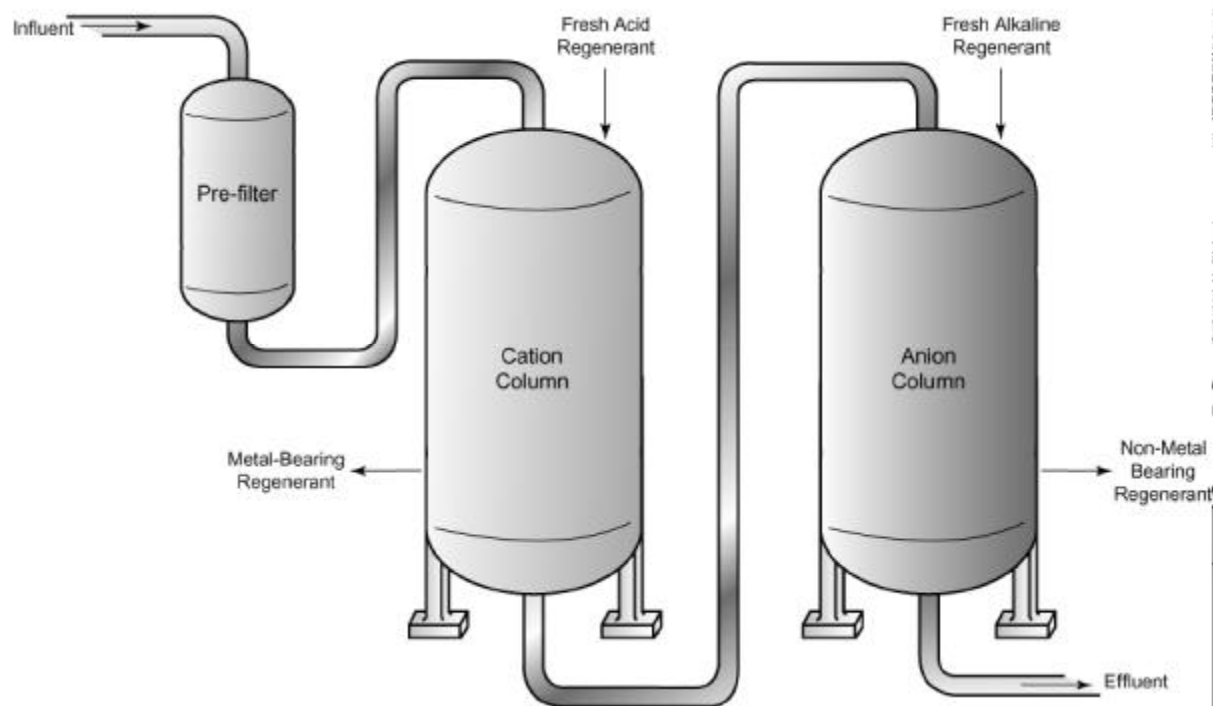


Figure 8-9. Typical Ion Exchange System

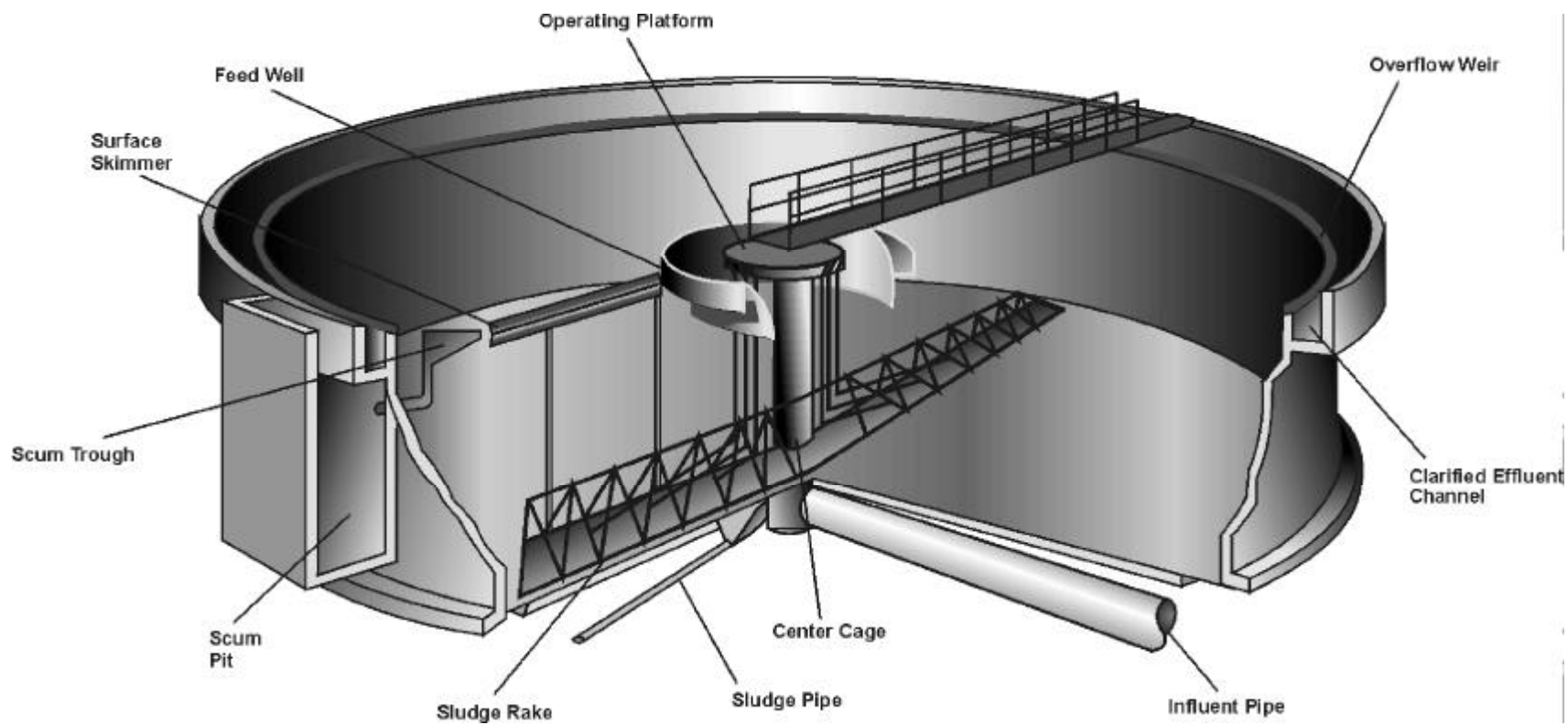


Figure 8-10. Typical Clarification System

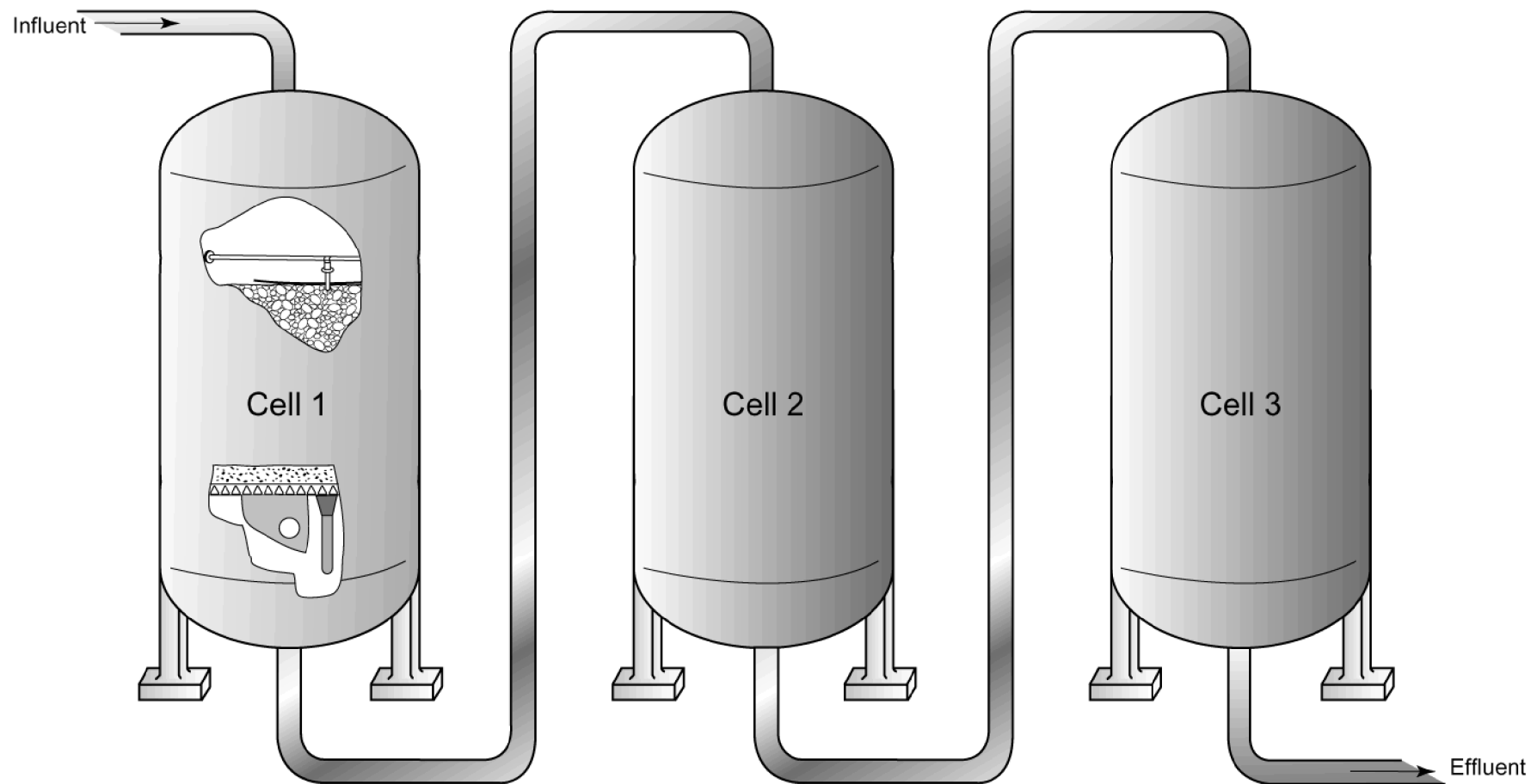
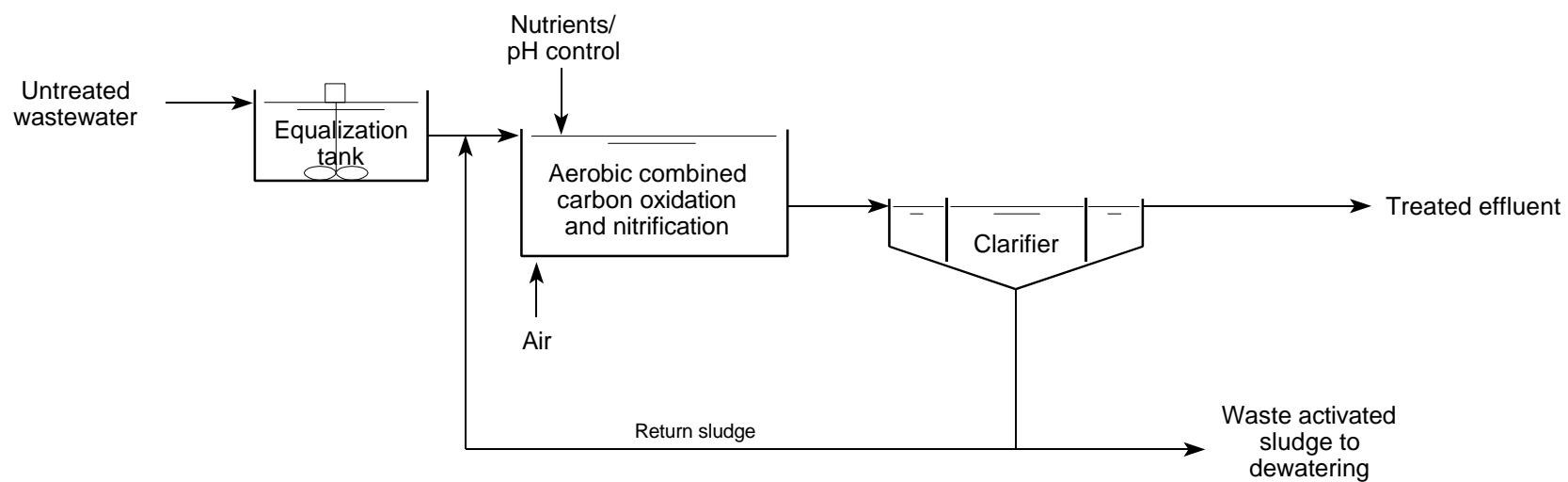


Figure 8-11. Typical Multimedia Filtration System



**Figure 8-12. Process Flow
Diagram of a Typical Biological
Treatment System**

Bio

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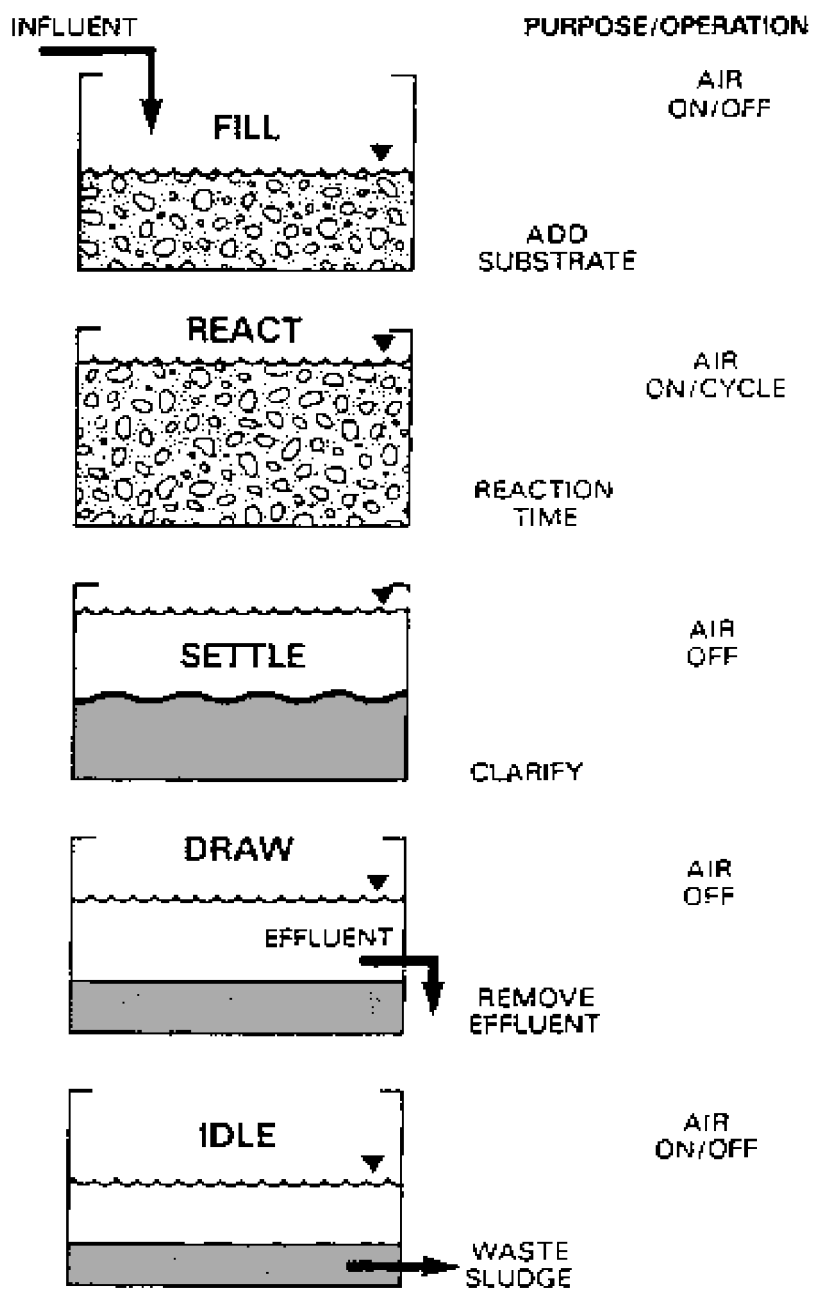


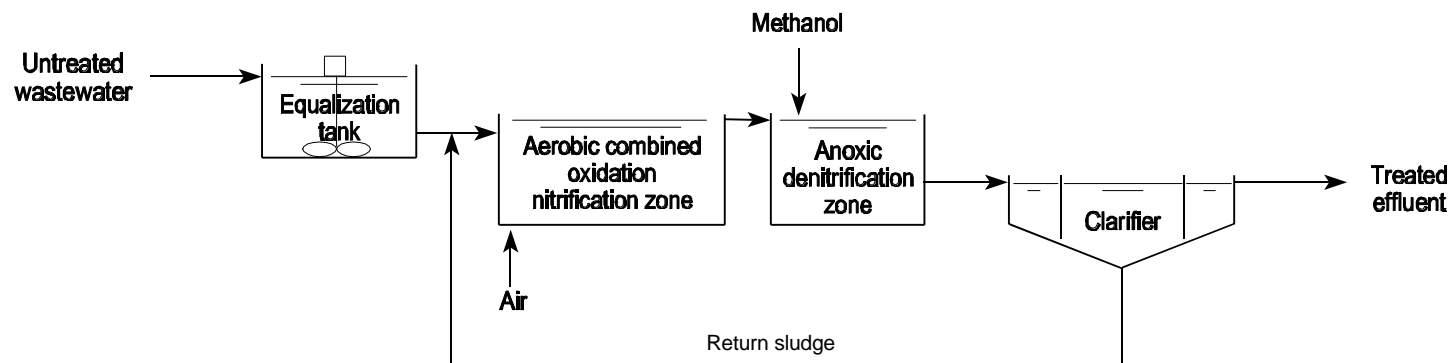
Figure 8-13. Typical Sequencing Batch Reactor Operation for One Cycle

SBR

4/03/02



A. End-of-pipe denitrification system using an external carbon source



B. Recycle denitrification system using untreated wastewater as a carbon source

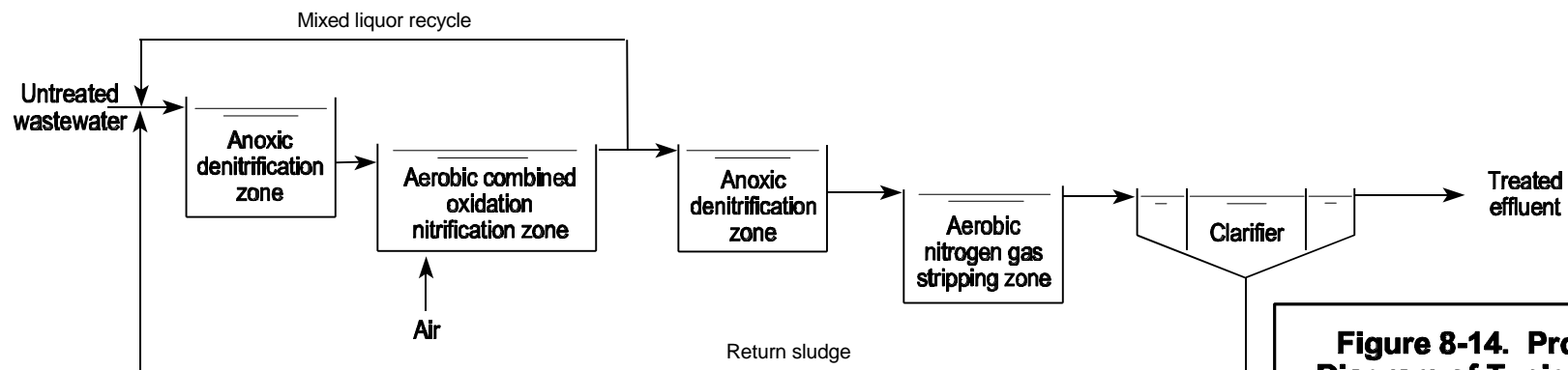


Figure 8-14. Process Flow Diagram of Typical Biological Denitrification Systems

Denit

10/03/00



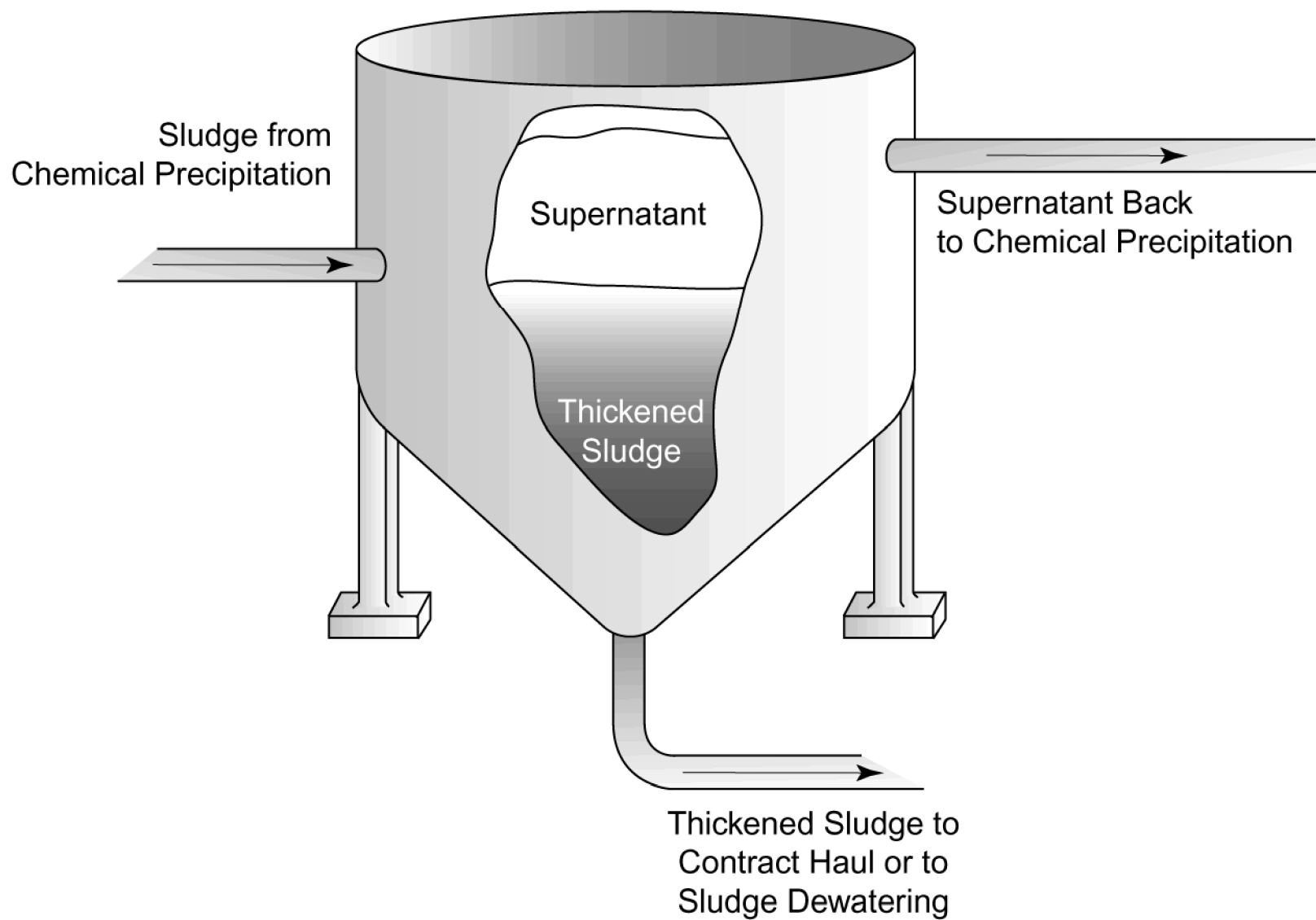


Figure 8-15. Typical Gravity Thickener

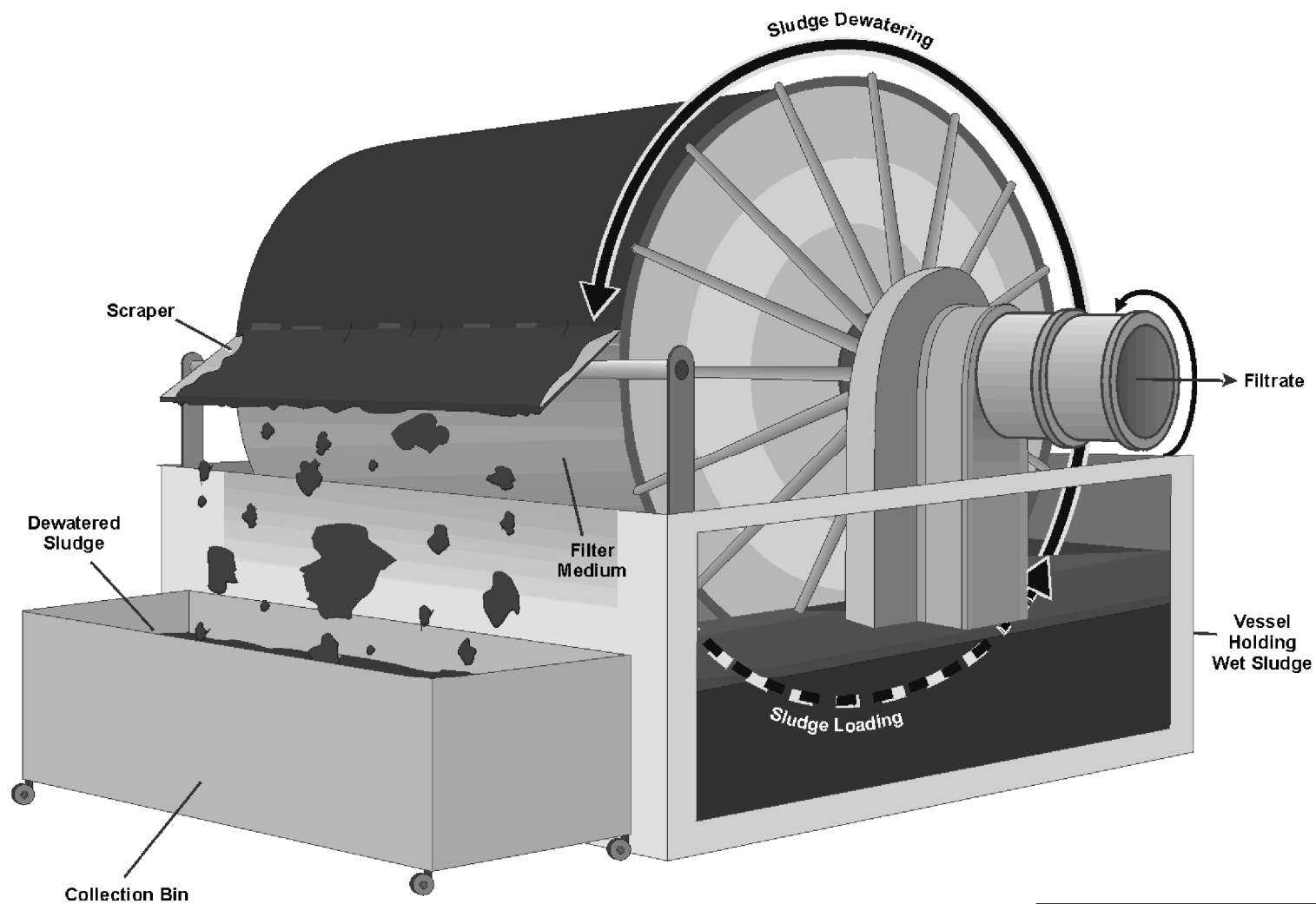


Figure 8-16. Typical Vacuum Filtration System

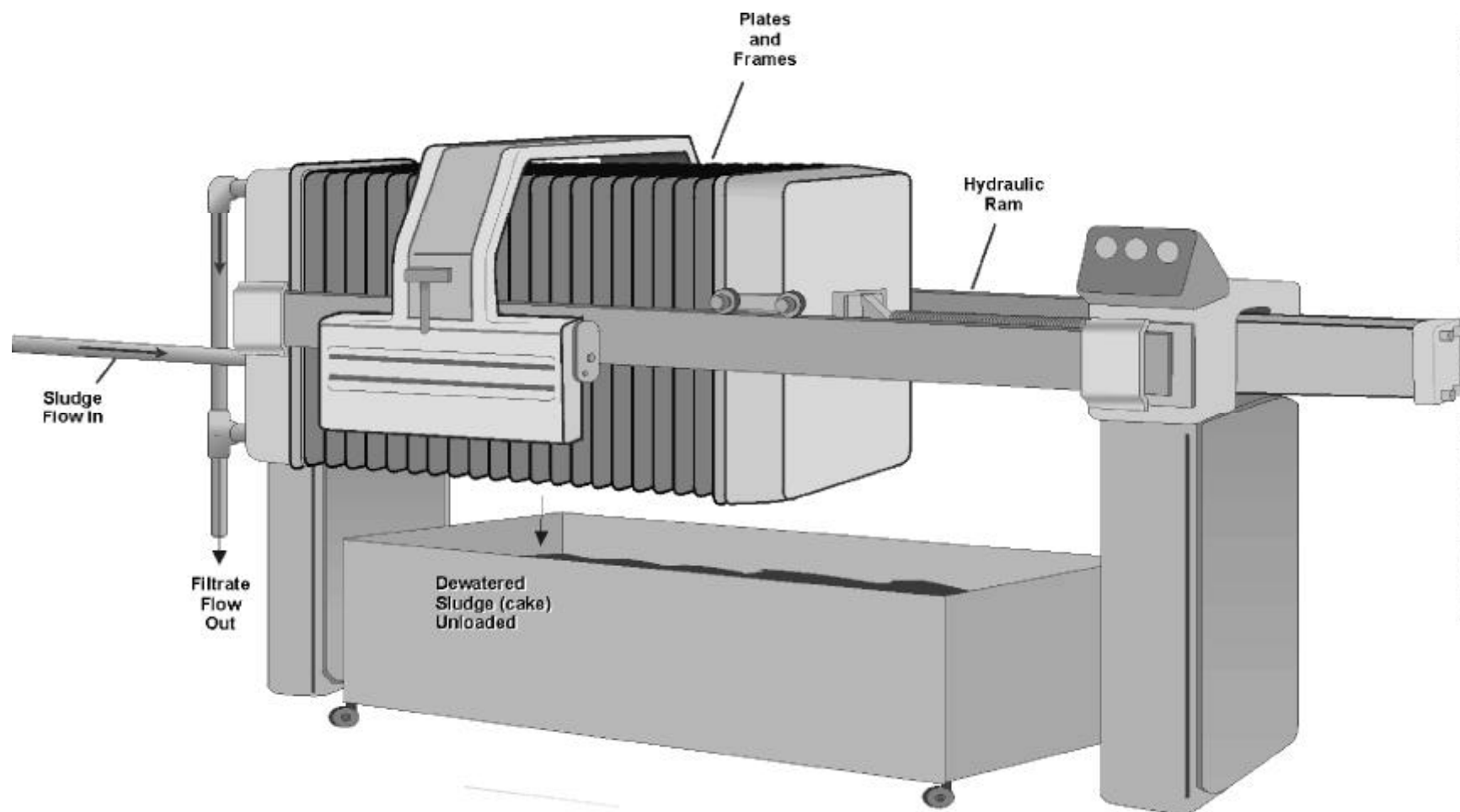


Figure 8-17. Typical Plate-and-Frame Filter Press